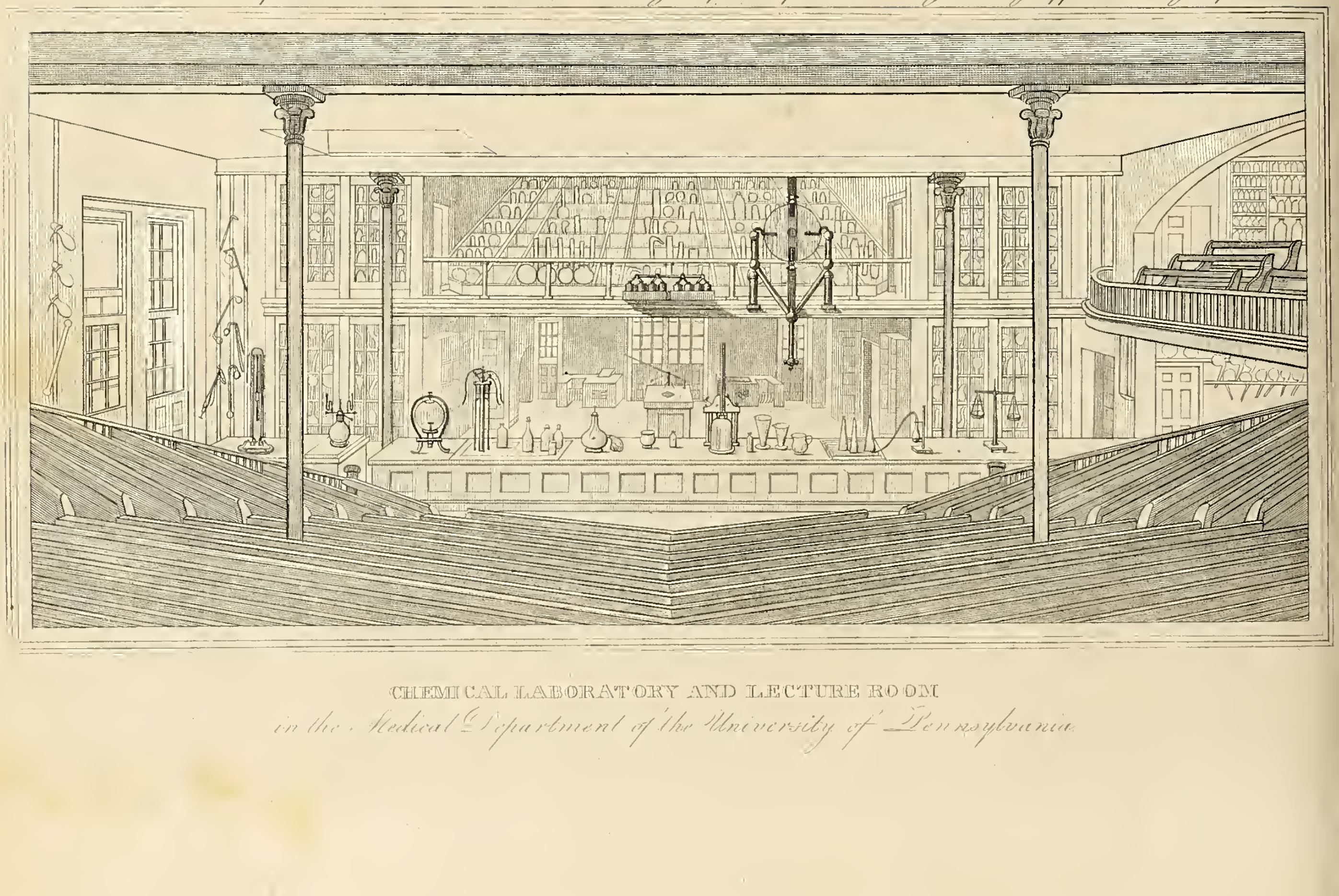
To Prof A. D. Bache
from his friend the
Author



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CHEMICAL LABORATORY AND LECTURE ROOM
*in the Medical Department of the University of Pennsylvania*

# EXPERIMENTAL OBSERVATIONS,

AND

# IMPROVEMENTS IN APPARATUS AND MANIPULATION;

WITH

## THEORETICAL SUGGESTIONS

## RESPECTING THE CAUSES OF TORNADOES, FALLING STARS, AND THE AURORA BOREALIS.

BY

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## ERRATUM.

Page 1, third line, for *true Sulphurous Ether*, read *true Sulphuric Ether*.

# ARTICLE I.

## *Observations on Sulphurous Ether, and Sulphate of Etherine (the true Sulphurous Ether). By R. Hare, M. D., Professor of Chemistry in the University of Pennsylvania.*

It is known that when two parts, by weight, of sulphuric acid are distilled with one of alcohol, a yellow sulphurous liquid is obtained. Berzelius alleges, that when this liquid is exposed in an exhausted receiver over sulphuric acid and hydrate of potash, an oleaginous liquid remains, which he designates as "*oil of wine containing sulphuric acid, or heavy oil of wine.*"

This oil is, by the same author, described as being heavier than water, as having a penetrating aromatic odour, and a cool pungent taste, resembling that of peppermint. It is, in fact, the liquid which Hennel first analysed as oil of wine, without, at the same time, mentioning the process by which it was procured. No doubt the difference between it and that procured by Boullay and Dumas, was, in some degree, the cause of the discordance between his observation and theirs. According to Hennel, the oil of wine consists of an atom of sulphuric acid, and an atom of hydrocarbon: $\dddot{S} + 4C + 4H$. By the last mentioned appellation, this skilful chemist designates a compound consisting of four atoms of carbon, and four of hydrogen.

Serullas represents the oil in question as consisting of two atoms of the acid, two of hydrocarbon or etherine, and one of water.

To the hydrocarbon of Hennel ($4CH$), as the common base of all the ethers, excepting those lately alleged to have mytheline for a base; the name of etherine has been given; so that the heavy oil of wine may be called the sulphate of etherine: or, according to the formula of Serullas, $2\dddot{S}E+H$, it is a hydrous sulphate of etherine. It is, in fact, the only compound to which the name of sulphuric ether can be applied with propriety. The yellow liquid out of which it is procured, as above stated, may be designated as the ethereal sulphurous sulphate of etherine.

Another oil, lighter than water, resulting from the distillation of the ethereal sulphurous sulphate of etherine, from hydrate of lime, or from potash, is described by Berzelius as oil of wine exempt from sulphuric acid. Of this the odour is represented as disagreeable; and, though nothing is said of its taste, it is to be presumed that it differs from the heavy oil of wine in this respect, as well as in its odour and specific gravity.

Thènard alleges, that when the heavy oil of wine is heated with water for some time, a liquid swims on the water, which, if refrigerated by ice, will, within twenty-four hours, deposit crystals. The mother liquid he calls light oil of wine, while to the crystals he gives the name of concrete oil of wine. Hennel mentions his having obtained a similar product by the reaction of oil of wine with water, or an aqueous solution of potash; and treats the crystalline matter as the base of the heavy oil of wine, deprived of its acid; or, in other words, as his "hydrocarbon;" or, as above mentioned, etherine.

Considering how much has been written on this topic, I am surprised that I have met with no statements respecting the reaction of ammonia with the above mentioned ethereal sulphurous sulphate of etherine.

Since the year 1818, I have been accustomed to saturate the acid in that liquid by ammonia. The residue, being rendered very fragrant, and entirely freed from its sulphurous odour, by admixture with about twenty-four parts of alcohol, was found to constitute an anodyne, possessing eminently all the efficacy of that so long distinguished by the name of Hoffman. When the residue, remaining after saturation with ammonia, was distilled in a water bath, ether came over, and left an oil which I was accustomed to consider as the oil of wine.

I had observed that, in the process above mentioned, there was a striking evolution of vapour, which seemed irreconcilable with the received opinion of the re-agents employed. Since the affinity between the ammonia and sulphurous acid is energetic, it did not appear to be reasonable that a copious escape of the one should be caused by its admixture with the other; and it was no less improbable that the vaporization of hydric ether, in its natural state, could take place at temperatures so much below its boiling point as those at which this phenomenon was noticed. In order to ascertain the truth, I luted a funnel, furnished with a glass cock and an air tight stopple, into the tubulure of a retort, of which the beak was so recurved downwards as to enter and be luted into the tubulure of another retort. The beak of the latter passed under a bell over water.

Both retorts were about half full of liquid ammonia, and surrounded with ice. The apparatus being thus arranged, about a thousand grains of the ethereal sulphurous sulphate of etherine were poured into the funnel, and thence gradually allowed to descend into the ammonia in the first retort. Notwithstanding the refrigeration, much heat was perceptible, and a copious evolution of vapour, which, passing into the second retort, was there absorbed or condensed, none being observed to reach the bell glass. At the close of the operation, hydric ether, holding oil of wine in solution, floated upon the ammonia in the first retort, and pure ether, of the same kind, floated on the ammonia in the second.

The ammonia in both retorts gave indications of the presence of sulphurous acid, on the addition of sulphuric acid. From these results, I inferred that a chemical compound of sulphurous acid and hydric ether formed the principal portion of the yellow liquid, and might be separated by distillation. Accordingly, by means of retorts arranged and refrigerated as above described, I procured a portion of sulphurous ether, which boiled at 44°, and which, when agitated with ammonia in a bottle, produced so much heat and consequent vapour, as to expel the whole contents in opposition to the pressure of my thumb. By employing the same distillatory apparatus, I subjected 2150 grains of the ethereal sulphurous sulphate of etherine to distillation, and obtained 726 grains of sulphurous ether, which boiled as soon as the frigorific mixture was removed from the containing retort. This being redistilled, as in a former experiment, so as to receive the product in ammonia, left in the retort five grains of oil of wine. The resulting ammoniacal liquid, saturated with chloride of barium in solution, gave a precipitate which, agreeably to the table of equivalents, contained 356 grains of sulphurous acid.

The residue of the 2150 grains of ethereal sulphate being subjected to distillation, raising the temperature from 95°, the point at which it had been before discontinued, to 140°, the product obtained by means of a refrigerated receiver weighed 602 grains. This was, of course, inferior in volatility to the first portion distilled; and, when redistilled, it was found to contain a small quantity of oil of wine. In fact, it appears, the boiling point of the ethereal sulphurous sulphate rises, not only as the ratio of the sulphurous acid lessens, but also as the proportion of oil of wine augments.

The residual liquid being exposed to the heat of a water bath at 212°; a very fragrant, and well flavoured oil of wine was evolved, and floated upon a quantity of water acidulated by sulphuric or sulphovinic acid.

Agreeably to another experiment, 1750 grains by weight, of the ethereal sulphurous sulphate of etherine, after washing with ammonia, gave 869 grains of an ethereal solution of oil of wine. This being subjected to distillation by a water bath raised gradually to 190°, there remained in the retort 148 grains of oil, beneath which there were a few drops of acidulated water. Agreeably to the result of several experiments, the ethereal sulphurous sulphate of etherine yields about half its weight of the ethereal solution of oil of wine. The quantity is always somewhat less than half when weighed; but the deviation is not greater than might be expected to result from the loss by evaporation, and the diversity of refrigeration employed in the condensation of the ethereal sulphurous sulphate, during the process by which it is evolved.

Under the expectation of procuring a sulphurous ether of a still higher degree of volatility, I associated with the apparatus usually employed in the process for generating hydric ether, a series of tubulated retorts, of which the beaks were recurved downwards in such a manner that the beak of the first communicated with a perpendicular tube, passing through an open-necked cylindrical receiver, so as to enter the tubulure of the second retort, of which the beak was in like manner inserted into a tube passing through a receiver in a third retort, and this communicated in like manner with a fourth retort. The second, third and fourth retorts, and the tubes entering them, were all refrigerated, the first with ice, the second with ice and salt, and the third with ice and chloride of calcium.

By these means, on subjecting to distillation in the first retort 48 ounces of alcohol of 830, and a like weight of sulphuric acid, besides the ethereal sulphurous sulphate of etherine usually resulting from the process, and condensing in the first receiver, it was found that in the other retorts severally, there were liquids of various degrees of volatility. That in the last boiled at 28°, but the boiling points rose gradually as the quantity of the residual liquid diminished.

In order to ascertain the nature of the sulph-acids abstracted from the ethereal sulphurous sulphate of etherine by the ammonia employed, chloride of barium was added in excess to the resulting ammoniacal solution, until no further precipitate would ensue. The liquid having been rendered quite clear by filtration, soon became milky. By evaporation to dryness, and exposure to a red heat, a residuum was obtained which proved partially insoluble in chlorohydric acid, and by ignition with charcoal, yielded sulphide of barium. It appears, therefore, that a hyposulphate of barytes existed in the liquid after it was filtered; as I believe that the hyposulphuric acid is the only oxacid of sulphur which is capable of forming with barytes a *soluble* compound, susceptible, by access of oxygen, of being converted into an insoluble sulphate, and precipitating in consequence.

It must be evident from the facts which I have narrated, that the yellow liquid obtained by distilling equal measures of sulphuric acid and alcohol, consists of oil of wine held in solution by sulphurous ether, composed of nearly equal volumes or weights of its ingredients; also, that the affinity between the *ether* and the acid is analogous to that which exists between alcohol and water. The apparent detection of sulphuric acid in the ammonia, justifies a surmise, that the etherine distils in the state of a hyposulphate, which subsequently undergoes a decomposition into sulphurous acid and sulphate of etherine.

The liquid above alluded to, as resulting from the saturation of the ethereal sulphurous sulphate of etherine by ammonia, and distillation by means of a water bath gradually raised to a boiling heat, is a very fragrant variety of oil of wine. It differs from that described by Berzelius as the heavy oil of wine of Hennel and Serullas, in being lighter and containing less sulphuric acid. I have a specimen exactly of the specific gravity of water, and have had one so light as to float on that liquid. The oil of wine obtained by ammonia approximates, in its qualities, to the variety which Thènard describes as light oil of wine. The presence of sulphuric acid in a definite or invariable ratio does not appear requisite to the distinctive flavour or odour of oil of wine.

The heavy oil of wine treated by Hennel as sulphate of hydrocarbon, $2\dddot{S}+4CH$; and by Serullas as a hydrous sulphate of etherine, $4CH+2\dddot{S}+\dot{H}$; I have obtained, as above mentioned, by exposing the ethereal sulphurous sulphate of etherine, in vacuo, over the hydrate of lime, or potash, and sulphuric acid. This variety sinks in water, being of the specific gravity of 1.09 nearly; is of a deeper hue than the other, and of a smell less active, with a taste somewhat more rank. A specimen of oil thus obtained being subjected to the distillatory process, a portion came over undecomposed, leaving in the retort a carbonaceous mass. 14 grains of the oil which had not undergone distillation, and a like portion of the distilled oil, were severally boiled in glass tubes with nitric acid until red fumes ceased to appear; about 28 grains of pure nitre were added to each, some time before the boiling was discontinued. The resulting liquid was in each case poured into a platina dish, boiled dry, and afterwards deflagrated by a red heat. The residual mass being subjected to water, the resulting solution was filtered, an excess of nitric acid added, and then nitrate of barytes in excess.

The precipitate obtained from the distilled oil, weighed, when dry, only nine and five-eighths grains, while that procured from the oil which had not been distilled, amounted, under like circumstances, to fourteen and one-eighth grains. Ten grains of another portion, left for some time over liquid ammonia, yielded only seven-eighths of a grain of sulphate.

About a drachm of Hennel's oil of wine was subjected to distillation with strong liquid ammonia; fourteen and a half grains came over, retaining the appropriate fragrance and flavour. This yielded, by the process above described, only two grains of sulphate of barytes. After all the water and ammonia had distilled, the receiver was changed, and fourteen grains of oil, devoid of the fragrance and flavour of the oil of wine, were obtained. This yielded one and one-eighth grains of sulphate. A carbonaceous mass, replete with sulphuric acid, remained in the retort.

Hennel states that when oil of wine was heated in a solution of potash, an oil was liberated which floated upon water, having but little fluidity when cold; and which, in some cases, partially crystallized. When gently heated, it became clear, and of an amber colour. The vapour had an agreeable, pungent, aromatic smell. This oil must have been pure etherine.

It is not improbable that this oil, which may be considered as devoid of sulphuric acid, is more or less liberated in evolving oil of wine, according to the nature of the process employed; and that the oil alluded to by Thènard, and those procured by me by simple distillation, ebullition, or distillation with ammonia or potassium, are mixtures of the etherine with its sulphate in various proportions. As it is well known that the odour of the essential oils is rendered more active by dilution, the livelier smell of the solutions may be consistent with a diminished proportion of the odoriferous matter.

Oil of wine cannot be distilled per se without partial decomposition, which does not take place below the temperature of 300. When subjected to the distillatory process, over potassium, at a certain temperature, a brisk reaction ensued, and the oil and metal agglutinated into a gelatinous mass. By raising the temperature the mass liquefied, and a colourless oil came over, which retained the odour of oil of wine. Meanwhile some of the potassium remained unchanged, and appeared within the liquid in the form of pure metallic globules. On pouring into the retort a portion of nitric acid in order to remove the caput mortuum, ignition took place from the presence of the potassium.

# ARTICLE II.

## *Of the Reaction of the Essential Oils with Sulphurous Acid, as evolved in union with Ether in the process of Etherification, or otherwise.* *By R. Hare, M. D., &c., &c., &c.*

Having mixed and subjected to distillation two ounces of oil of turpentine, four ounces of alcohol and eight ounces of sulphuric acid, a yellow liquid came over, having all the appearance of that which is obtained in the process for making oil of wine, described in the preceding article. On removing, by means of ammonia, the sulphurous acid existing in the liquid, and driving off the ether by heat, a liquid remained, which differed from oil of turpentine in taste and smell, although a resemblance might still be traced. This liquid was without any sensible action on potassium, which continued bright in it for many weeks. It proved, on examination, to contain a small quantity of sulphuric acid. I ascertained, afterwards, that in order to produce these results, it was sufficient to pour oil of turpentine on the mass which remains after the termination of the ordinary operation for obtaining ether, and apply heat. Subsequently it was observed that when the sulphurous ether was removed by heat or evaporation, without the use of the ammonia, the proportion of sulphuric acid in the remaining oil was much greater.

By subjecting to the same process several essential oils, I succeeded in obtaining as many liquids to which the above remarks were equally applicable. With some of the oils, however, similar results were, by this method, either totally or partially unattainable, in consequence of their reaction with the sulphuric acid being so energetic as to cause their decomposition before any distillation could take place. No product can be obtained by distillation with sulphuric acid and alcohol from the oil of cinnamon obtained from cassia. From the oils of sassafras and cloves, but little can be procured.

However, in one instance, by previously mixing the oil of sassafras with the alcohol, in the manner described in the account given of the first experiment with the oil of turpentine, I succeeded in obtaining, in addition to a small quantity of the heavy liquid containing sulphuric acid, a minute quantity of a lighter one, devoid of that acid, which burned without smoke, was insoluble in water, and very fluid. I am disposed to consider the liquid thus procured as a hydrate of sassafras oil, or sassafreine, as I would call it, being analogous to hydric ether.

The oil of sassafras, whether isolated or in combination, possesses a remarkable property, which, I believe, has not attracted sufficient observation: I mean that of producing an intense crimson colour, when added, even in a very minute quantity, to concentrated sulphuric acid.

One drop of oil of sassafras imparted a striking colour to forty-eight ounce measures of sulphuric acid, and appeared perceptible when it formed less than a five millionth part. This property was completely retained by the lighter liquid above described as procured from oil of sassafras.

I subsequently observed, that when sulphurous acid, whether in the form of sulphurous ether, in that of a gas, or when in union with water, was brought into contact with any of the essential oils (including kreosote), which were subjected to the experiment, they acquired a yellow colour, and a strong smell of this acid.

In the case of the yellow compound thus obtained from any of the essential oils which I have tried, if the sulphurous acid be removed by heat, the oil, by analysis, will be found to yield sulphuric acid. That some acid of sulphur remains in union must be evident, since washing with ammonia will not entirely remove the power of yielding sulphuric acid; and the total absence of the sulphurous smell demonstrates that the sulphurous acid either enters into an intimate combination with the oil, or acquires oxygen sufficient to convert it into sulphuric or hyposulphuric acid.

Those essential oils which contain oxygen, are most affected by the action of sulphurous acid.

Both the oils of cloves and cinnamon, after admixture with sulphurous ether and subsequent distillation, gave, on analysis, precipitates of sulphate of barytes. In the case of cloves, the precipitate amounted to one-seventh of the whole weight.

By distilling camphor with alcohol and sulphuric acid, I obtained a yellow liquid, which, by washing with ammonia and evaporation, in order to get rid of the sulphurous ether, yielded an oil. The oil, by standing, separated into two portions, one solid, the other liquid. The solid portion resembled camphor somewhat, in smell, but differed from it by melting at a much lower temperature, becoming completely fluid at 175°.

I found that the essential oils of cinnamon and cloves possessed an antiseptic power, quite equal to that of kreosote, and that their aqueous solutions, when sulphated, were even superior to similar solutions of that agent.

One part of milk mingled with four parts of a saturated aqueous solution of the sulphated oil of cloves, remained after five days sweet and liquid, while another portion of the same milk became curdled and sour within twenty-four hours. Having on the 2d day of July added two drops of oil of cinnamon to an ounce measure of fresh milk, it remained liquid on the 11th; and, though it finally coagulated, it continued free from bad taste or smell till September, although other portions of the same milk had become putrid. A half ounce of milk, to which a drop of sulphurous oil of turpentine had been added, remained free from coagulation at the end of two days, while another portion, containing five drops of pure oil of turpentine, became curdled and sour on the next day.

A number of pieces of meat were exposed in small wine glasses, with water impregnated with solutions of the various essential oils. Their antiseptic power seemed to be in the ratio of their acridity. The milder oils seemed to have comparatively little antiseptic power, unless associated with the sulphurous acid, which has long been known as an antiseptic.

In cutaneous diseases, and, perhaps, in the case of some ulcers, the employment of the sulphurous sulphated oils may be advantageous.

A respectable physician was of opinion that the sulphurous sulphate of turpentine had a beneficial influence in the case of an obstinate tetter.

Possibly the presence of sulphurous acid may increase the power of oil of turpentine as an anthelmintic.

Pieces of corned meat hung up, after being bathed with an alcoholic solution of the sulphurous sulphated oil of turpentine, or with solutions of the sulphated oils of cloves or cinnamon, remained free from putridity at the end of several months. That imbued with cinnamon had a slight odour and taste of the oil.

I am led, therefore, to the impression that the antiseptic power is not peculiar to kreosote, but belongs to other acrid oils and principles, and especially to the oils of cinnamon and cloves.

The union of sulphuric acid with these oils appears to render them more soluble in water: whether any important change is effected in their medical qualities by the presence of the acid may be a question worthy of attention.

I have stated my reasons for considering the ammoniacal liquid, resulting from the ablution of the ethereal sulphurous sulphate of etherine with ammonia, as partially composed of hyposulphuric acid. By adding to this ammoniacal liquid a quantity of sulphuric acid, sufficient to produce a strong odour of sulphurous acid, and then a portion of any of the essential oils; a combination ensued, as already described, between the oils and the sulphurous acid liberated by the sulphuric acid, so as to render them yellow and suffocating. The habitudes of cinnamon oil from cassia under these circumstances were peculiar. A quantity of it was dissolved, communicating to the liquid a reddish hue. The solution being evaporated, a gummy translucent reddish mass was obtained, which, by solution in alcohol, precipitated a quantity of salt, and being boiled nearly to dryness, re-dissolved in water, and again evaporated, was resolved into a mass having the friability, consistency and translucency of common rosin; but with a higher and more lively reddish colour. Its odour recalls, but faintly, that of cinnamon ; its taste is bitter and disagreeable, yet recalling that of the oil from which it is derived. Its aqueous solution does not redden litmus; nor, when acidulated with nitric acid, does it yield a precipitate with nitrate of barytes.

Of this substance ten grains were exposed to the process above mentioned, for the detection of sulphuric acid, and were found to yield a precipitate of 6.5 grains of sulphate of barytes.

It may be worth while to mention, that in boiling the sulphated oils with nitric acid, compounds are formed finally, which resist the further action of the acid, and are only to be decomposed by the assistance of a nitrate and deflagration. I conjecture that these compounds will be found to merit classification as ethers formed by an oxacid of nitrogen.

One of my pupils, in examining one of the compounds thus generated, was, as he conceived, seriously affected by it, suffering next day as from an over dose of opium. He also conceived that a cat, to which a small quantity was given, was affected in like manner.

I had prepared an apparatus with the view of analyzing accurately the various compounds above described or alluded to, by burning them in oxygen gas ; when, by an enduring illness of my assistant, and subsequently my own indisposition, I was prevented from executing my intentions.

# ARTICLE III.

## *Of Sassarubrin, a Resin evolved by Sulphuric Acid from Oil of Sassafras, which is remarkable for its efficacy in Reddening that Acid in its concentrated state. By R. Hare, M. D., &c., &c., &c.*

This colour is due to a peculiar resin, which I would call sassarubrin, being elaborated from the oil of sassafras, by its reaction with sulphuric acid, with phenomena which are striking, and, in some respects, singular. If a mixture be made of equal parts of the oil of sassafras, alcohol and sulphuric acid, on raising the temperature to a certain point, the whole mass rises up in a resinous foam, of a beautiful colour, between copper and purple, with a metallic brilliancy. In some instances, it has been partially forced out of the retort through the beak in a cylindrical mass, which acquired, on cooling, the consistency of pitch. This pitchy substance is a compound of the resin above alluded to and sulphuric acid, with which it forms a soluble substance, neutralising its sourness to a certain extent. By steeping this subacid compound in ammonia, straining, washing the residue with water, and desiccation, a brittle tasteless resin remains, which is quite insoluble in water, but very soluble in alcohol and hydric ether.

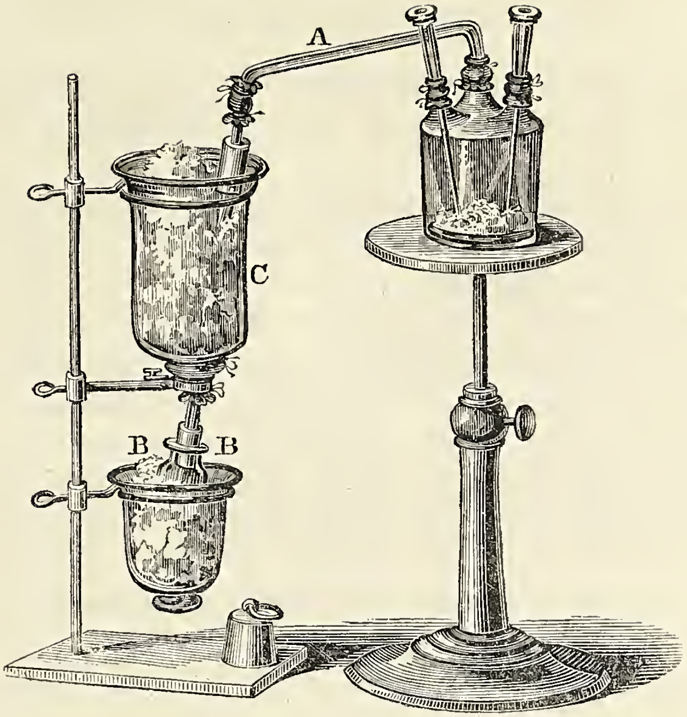
The addition of this sassarubrin to concentrated sulphuric acid, produces the crimson colour already mentioned as resulting from the presence in that liquid of a minute portion of oil of sassafras. I infer that the colour is due to the evolution of sassarubrin, which has a bassic affinity for the acid, to which it owes its birth. The ethereal and alcoholic solutions of sassarubrin are of the colour of a dingy white wine, but acquire a deep crimson when mingled with concentrated sulphuric acid.

Sassarubrin may be produced by the union of the acid and oil, provided it be moderated by refrigeration or dilution with water.

Without some precaution, the heat produced is sufficient to char the resin more or less. The reddening influence of the oils of cinnamon and cloves is due to the generation of resins analogous to sassarubrin.

To those resins the names of cinnarubrin and clovorubrin may be severally assigned. Cinnarubrin may be evolved by adding oil of cinnamon to equal parts of sulphuric acid and water, previously mixed and refrigerated, the temperature being subsequently elevated till the mass rises up in a foam; when the whole should be poured into a solution of pearlash, from which the resin may be extricated by a strainer. It is analogous to sassarubrin, but is less efficacious in colouring sulphuric acid, and does not, like the former, impart to the sides of the containing glass a rich red colour. Moreover, it appears to be partially insoluble in alcohol, and to retain sulphuric acid after being boiled with an alkaline solution.

I infer that a new series of resins may be evolved from the essential oils by their reaction with sulphuric acid; which, having a general analogy to each other, may still have discriminating characteristics, arising from the oils whence they may be derived.



# ARTICLE IV.

## *Process for Nitric Ether, or Sweet Spirits of Nitre, by means of an approved Apparatus. By R. Hare, M. D., &c., &c., &c.*

The reaction of nitric acid with alcohol is so difficult to regulate, in the ordinary mode of making nitric ether in which the whole of the materials are mingled at the outset of the process, that I was induced, about twelve or fifteen years ago, to introduce an apparatus in which they were gradually added together within a glass bottle, by means of glass funnels with glass cocks.

Subsequently I adopted the more simple apparatus represented in the accompanying figure.

Providing a bottle with three tubulures, let one tubulure communicate, by means of a recurved tube A, with another tube passing perpendicularly through an open-necked inverted receiver C, and entering a bottle surrounded with ice and salt, occupying a suitable vessel B B. The cavity of the receiver should likewise be occupied by a freezing mixture.

Into each of the remaining tubulures let a glass tube be introduced, ground or luted to fit air tight, and tapering so as to terminate in a capillary orifice near the bottom of the bottle.

Through one of the tubes introduce as much alcohol as will cover the bottom of the bottle, and then, by means of the other tube, introduce as much strong nitric acid as will cause an effervescence. Should the effervescence threaten to become explosive, the reaction may be checked by the further addition of alcohol, and when the reaction appears to decline too much, it may be re-excited by an additional quantity of acid. By these means, without applying heat, a quantity of nitric* ether will soon be condensed in the refrigerated bottle. To convert this ether into a liquid, fully equal to the officinal sweet spirits of nitre, let it be mingled with seven parts of alcohol, and four of water.

The colder the freezing mixture, the greater will be the product; yet more or less may be obtained by refrigeration with cold water.

It may be proper to mention, that at the bottom of the phial an aqueous acid liquor is deposited, upon which the ether swims, and from which it should be carefully separated.

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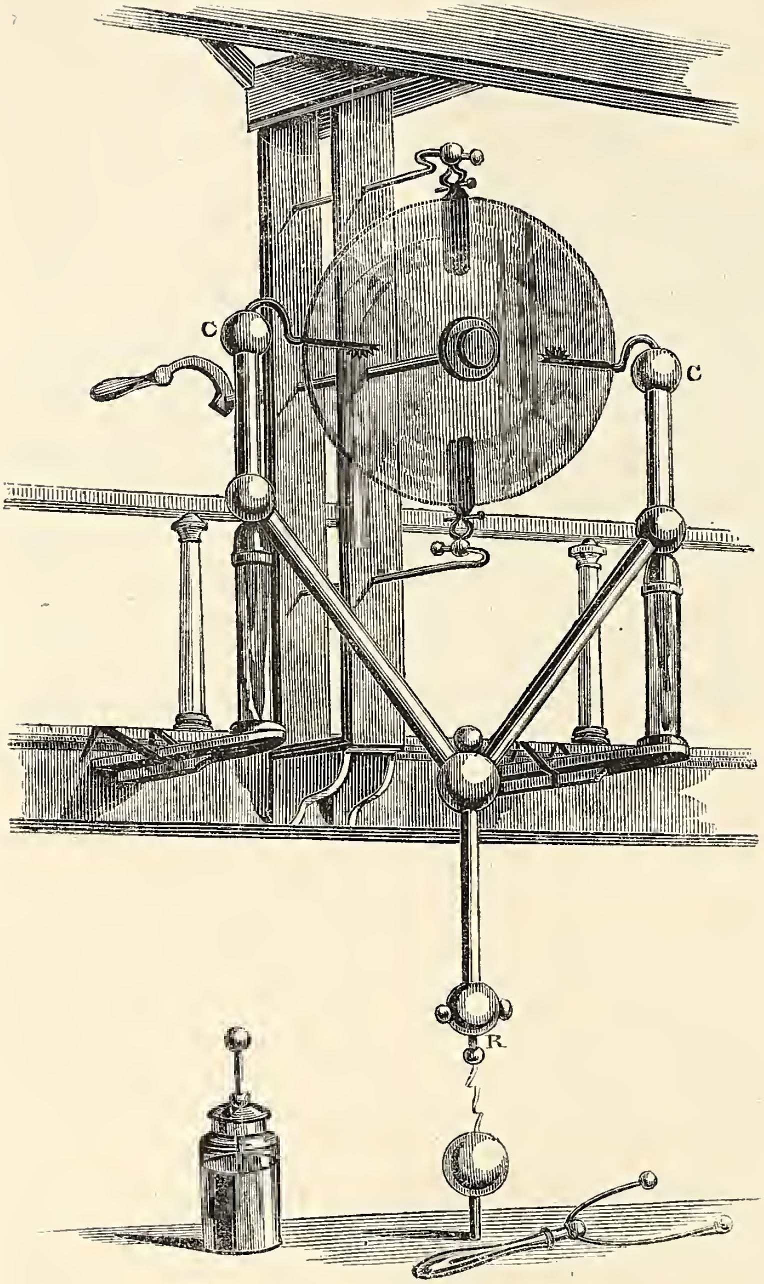
* The proper appellation of this ether being unsettled, I adhere to that generally used.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## ARTICLE V.

### *Description of an Electrical Machine, with a Plate four feet in diameter, so constructed as to be above the Operator: also of a Battery Discharger employed therewith: and some Observations on the Causes of the Diversity in the Length of the Sparks erroneously distinguished by the terms Positive and Negative. By R. Hare, M. D., &c., &c., &c.*

The opposite engraving represents a machine with a plate four feet in diameter, which I have recently constructed so as to be permanently affixed to the canopy over the hearth of my lecture room.

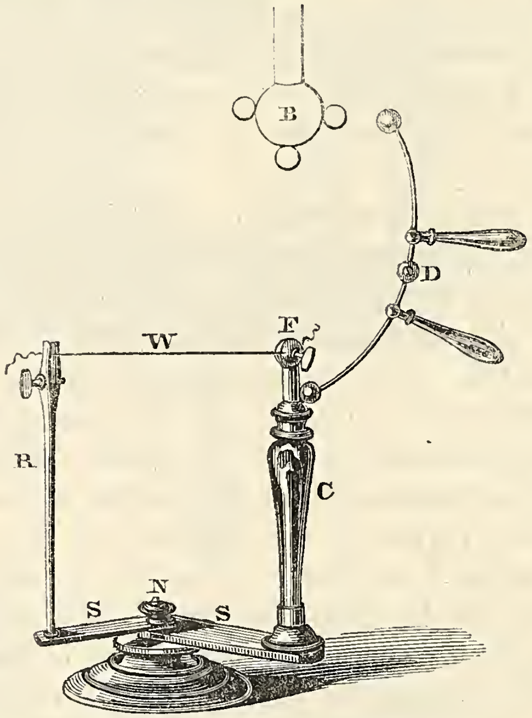
This situation I have found convenient even beyond my expectations, as the machine is always at hand, yet never in the way. In lecturing, with the aid of a machine on the same level with the lecturer, one of two inconveniences is inevitable. Either the machine will occasionally be between him and a portion of the audience, or he must be between a portion of the audience and the machine. Situated like that which I am about to describe, a machine can neither hide the lecturer, nor be hidden by him. With all its power at his command, while kept in motion by an assistant, he has no part of it to reach or to handle besides the knob and sliding rod of the conductor, which are in the most convenient situation.

The object of this machine being to obtain a copious supply of electricity for experiments, in which such a supply is requisite, it was not deemed necessary to insulate the cushions and the axis, as in the electrical plate machine which I employ for experiments requiring insulation.*

The prime conductor is supported and insulated by means of wooden posts covered by stout bell glasses, so that the summits of the latter are between those of the posts and the inner surfaces of caps attached to the conductor. By these means the glass is subjected to pressure, but is liable to no strain. Such a support combines the advantages both of wood and glass. At C C, are the collectors. R represents a sliding rod, which may be drawn out to such an extent as to be brought in contact with any apparatus placed under it upon the table.

In fact, the large rod in which the rod R slides may be slipped up to any elevation through the hole in the brass ball which sustains it.

### DR. HARE'S BATTERY DISCHARGER FOR DEFLAGRATING WIRES.



This apparatus is employed by me in lieu of Henley's universal discharger; being better adapted to my apparatus, and mode of operating. Two brass plates, S S, are secured to the pedestal by a screw bolt N, which passes through a hole made in each, near one extremity: the plates are thus allowed a circular motion about the bolt, so as to be set in one straight line, or in any angle with each other. On one of the plates near the extremity not secured by the bolt, a brass socket is soldered, into which a glass column C is cemented, surmounted by a forceps. At the corresponding end of the other plate, there is a brass rod R, perpendicular to the plate, and parallel to the glass column. This rod is also furnished with forceps. Between these forceps, and those at F, supported and insulated by the glass column C, a wire is stretched, which may be of various lengths, according to the angle which the plates S S make with each other. The pedestal should be metallic, or have a metallic plate at bottom, in communication with the external coating of the battery. This being accomplished, it is only necessary to charge the battery, without subsequently breaking the communication between the inner coatings of the jars, and the prime conductor, by which the charge is conveyed. In that case, touching the conductor is equivalent to a contact with the inner coatings of the jars, so far as electrical results are concerned. Hence, by causing one of the knobs of the discharger D, with glass handles, to be in contact with the insulated forceps F, and then approximating the other knob to the prime conductor B, the charge of the battery will pass through the wire W, as it cannot descend by the glass column, nor reach the operator through the glass handles. These should be longer than represented in the cut.

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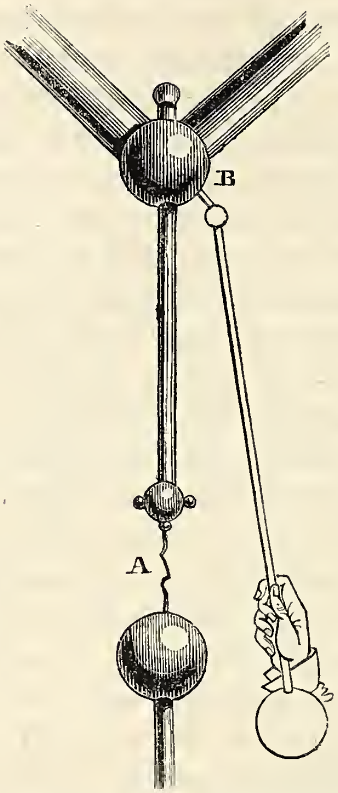
* See Silliman's American Journal of Science for 1828, vol. 7, page 108; or London Philosophical Magazine for 1823, vol. 23, page 8.

## LONG ZIGZAG OR ERRATIC SPARK, CONTRASTED WITH THE SHORT STRAIGHT SPARK.

"The cause of this difference between the lengths of the two electricities, we have no means of explaining."—*Thompson's work on Heat and Electricity.*

The object of the engraving on the following page is to represent the different forms and lengths of the electric spark, which take place between a large and a small ball, accordingly as they are made negative or positive. The long and zigzag, or erratic spark A takes place between a small ball attached to the positive pole, and a large one associated with the negative pole. The short straight spark B is eli-



cited under circumstances the reverse of those just mentioned. They are represented as simultaneous, but, with the same machine, can of course, only be obtained in succession.

In no respect do the phenomena of mechanical electricity appear more favourable to the Franklinian theory, and more inexplicable, according to the doctrine of two fluids, than in the diversity of the electrical spark in passing between a small and a large metallic ball, according to the manner in which the balls are associated with the positive or negative poles of the machine. When the small ball is attached to the positive pole, the spark is long, comparatively narrow, and of a zigzag shape, such as lightning is often seen to assume; but when the situation of the balls is reversed, the spark is straight and thick, not one-third as long, and nothing of a zigzag shape can be observed in it.

According to the Franklinian theory, when any body is more highly charged with electricity than the adjoining bodies, the excess of the fluid is attracted by them, while it is inadequately repelled by the inferior quantity of the electric fluid, with which they are imbued. It follows that when a small globe is made positive in the neighbourhood of a large one, the excess of electric matter in the former, is attracted by all the negatively excited metal in the latter. When the small globe is made negative, the metal of which it consists attracts all the electric matter in the large globe. Hence there is this difference in the two cases; the small globe being positive, a comparatively small *movable mass* of electric matter, is attracted by a large immovable mass of metal: the small globe being made negative, a large *movable mass* of electric matter is attracted by a small immovable mass of metal. The charge being in both cases the effect of the same machine; the attractive power must be as great in one case as in the other. The forces by which the masses are actuated being therefore equal, it is quite reasonable that the greatest projectile power should be attained, when the small mass is movable. In that case, it will require less air to be removed in order to effect a passage.

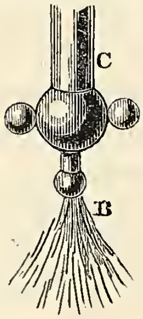
There is an analogy between the difference which I suppose to exist in the case under consideration, and that which may be observed between the penetrating power of a rod which is blunt, and one which is pointed.

It remains to show why a large mass of electric matter will be discharged in a spark when there is sufficient proximity, although that electric matter be situated in the large globe, and attracted by the other, under circumstances in which, as above stated, it would not pass without that proximity.

It must be evident that attraction increases, as the distance between the bodies which exercise it lessens. Of course the attraction of the small globe must always act more powerfully on those portions of the electric fluid, which occupy the nearest parts of the positively excited globe. But this difference of distance, and consequent diversity of attraction, increases as the globes are approximated. Thus that portion of the electric fluid which sustains this pre-eminent attraction, will be accumulated into a conoid; the acuteness of which, and attraction causing the acuteness, increasing with the proximity, there will at last be sufficient projectile and penetrative power to break through the air, and thus open a passage for the whole of the quantity attracted by the small negatively excited globe.

When, by the process last described, the fluid is made to leap through a comparatively small interval, by the concentrated attraction exercised by a small negative ball upon the expanded surface of electric matter diffused through a large globe, the air does not become sufficiently condensed to resist it before it reaches its destination, and, of course, it cannot assume the erratic form which would arise from repeated changes in its course, as in the instance of the long spark.

### OF THE ELECTRICAL BRUSH.



When the machine is in active operation, and the prime conductor insulated; from a small knob attached to it, as at B, in the figure, the electricity will be so sent off, as by the concomitant light to exhibit the form of a luminous brush, as represented in this figure at B. For the production of this phenomenon, it is necessary that the electric fluid shall be condensed into a small prominent mass, so as, agreeably to the preceding explanation, to have great penetrating power. This it cannot possess, when, with the same intensity in the generating power, a large ball is positively electrified. In that case, the electric column presents a front too broad to procure a passage through the surrounding non-conducting air. A small ball, negatively electrified, can only be productive of a diffuse attraction for the electricity in the atmospheric medium around it; so that it has less ability to create any penetrating power, than when acting upon the electricity in a comparatively large globular conductor, as in the preceding illustration. Hence, when the knob is on the negative pole, it may be productive of a luminous appearance in its immediate vicinity, where the electric matter, converging from the adjoining space, becomes sufficiently intense to be productive of light; but it does not produce the striking appearance of the luminous brush.

As, agreeably to Du Fay's theory, the knob, whether vitreously or resinously electrified, is surcharged with an electric fluid, the projectile power ought to be as great in the one case as in the other; and the long spark and the brush, should be producible in either case.

## ON SOME INFERENCES FROM THE PHENOMENA OF THE ELECTRIC SPARK, IN A RECENT WORK ON HEAT AND ELECTRICITY.

*By the Author of the preceding Article.*

In his valuable work on heat and electricity, Dr Thompson states that if a long spark be taken between two knobs, as when severally attached to the positive and negative conductors of the electrical machine; the portion of the spark near the positive knob exhibits all the characters of positive electricity, while the remaining portion proceeding from the other knob displays all the characters of negative electricity. Although the learned and ingenious author does not state what differences there are between the different portions of the spark, and wherefore, if any exist; he can, without a petitio principii, assume that they are such as to justify his conclusion. He proceeds to allege that there can be no doubt that every spark consists of two electricities; which, issuing severally from their respective knobs, terminate their career by uniting at the non-luminous portion of the spark, which is at a distance from the negative knob, of about one-third of the interval. Upon these grounds he infers that the positive electricity occupies two-thirds of the length of the spark, the negative one-third.

I presume that, agreeably to the theory which supposes the existence of two fluids, when the equilibrium between oppositely excited surfaces is restored by a discharge, whether in the form of a spark or otherwise, there must be two jets or currents passing each other; the one conveying as much of the resinous as the other does of the vitreous electricity. Of course no part of a spark can be more negative than it is positive, nor more positive than it is negative. Upon this ground, a suggestion of the same author, that the diminution of light near the middle of the spark results from the combination of the different fluids at this point, appears to me injudicious, since there is as little ground for supposing the union of the fluids to take place there as elsewhere. But admitting that the union does take place as supposed, is this a reason for the observed diminution of light? If, when isolated, either fluid is capable of emitting a brilliant light, should not their co-operation increase the effect? If, after their union, they do not shine, it can only be in consequence of their abandoning, at that moment, all the light with which they were previously associated. It cannot be imagined that the light accompanying one should neutralize that accompanying the other.

In deflagrating, by voltaic electricity, a wire of uniform thickness, equally refrigerated, the most intense evolution of heat and light is always midway.

In truth, the theory which the learned author sanctions, requires two postulates so irreconcilable, that unless one be kept out of view, the other cannot be sustained. It requires that the fluids should exercise an intense reciprocal attraction adequate to produce chemical affinity, and of course, enter into combination when they meet, and yet rush by each other with inconceivable velocity, not only through the air, but also through the restricted channel afforded by a small wire. If the fluids combine at a point intervening between the surfaces from which they proceed, what becomes of the compound which they form? Is it credible that such a compound would afford no indication of its existence? But, again, how are two surfaces, the one previously deprived of a large portion of the negative electricity naturally due to it, the other made as deficient of the positive fluid, to regain their natural state? By a combination midway, the resinous and vitreous surcharges might be disposed of, but whence could the vitreous and resinous deficiencies be supplied?

Dr Thompson, in common with the great majority of modern chemists, ascribes chemical affinity to the attraction between the two electricities combined with ponderable particles. As the combinations between such particles take place only in definite proportions, would it not be consistent that the fluids which give rise to them, should combine agreeably to those laws? But if the electrical compound, formed of the vitreous and resinous electricities, be decomposable by induction, as the theory in question requires, its constituents must be capable of uniting in every proportion.

Agreeably to the late investigations of the celebrated Faraday, equal quantities of the electric fluid are evolved by analogous chemical changes, in equivalent weights of different ponderable bodies. It may therefore be inferred, that in entering into combination the electric fluid is obedient to those laws of definite proportion which regulate other substances.

# ARTICLE VI.

## *On the Causes of the Tornado, or Water Spout. By R. Hare, M. D., &c., &c., &c.*

In July last, I visited the scene of the tornado, which had in the previous month produced so much damage in and near New Brunswick, New Jersey, and heard it described by various witnesses, and have likewise been edified by the observations made respecting its effects by professors Henry, Torrey, Johnson and other sagacious and learned observers, and especially those of my friends, professor A. D. Bache, and Mr Espy. Probably in no other instance have the effects of a tornado been so faithfully and skilfully traced, ascertained and registered. Professor Bache regularly surveyed the path of the devastating agent, and ascertained the bearings of the various bodies prostrated by it, so as to make several accurate plots.* From an examination of these, the proximate causes of the changes effected, are those of a vertical current at the centre or axis of the tornado, and of a horizontal conflux of the air towards that axis from the surrounding space. Some trees appear to have been thrown down on the approach of the hiatus, both directly in front of it and on either side; some fell at right angles, others obliquely to the path. Hence they were found to have a great variety of bearings, but always pointing towards the path.

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* I hope that these plots will appear in this volume.

The time of their falling, and consequently the direction agreeably to the observations of professor Bache, appear to have been determined not only by the extent of the force to which they were exposed, but likewise by the strength of their roots, or the degree of protection afforded them by other bodies, trees or houses for instance. On these accounts, neighbouring trees, falling at different times, had different bearings ; but that they all fell towards the point occupied by the axis of the tornado at the time of their overthrow, appears to be consistent with the facts. In one instance, both professor Bache and Mr Espy observed that the post of a frame building, being dislodged from the stone on which it rested, was first moved towards the path of the tornado in one direction about eighteen inches, marking its course by a furrow in the ground, and afterwards moved in another direction, nearly at right angles to the former, leaving a similar indication of the course in which it had moved. Intermediately between the time when the tornado bore in those directions, the frame was protected bya house.

While the phenomena above described sufficiently indicate the existence of a horizontal conflux of the air, that of a vertical force was demonstrated by the transportation of the debris of the houses and trees, as well as lighter bodies, to a great distance. A lady's reticule was carried seven miles from New Brunswick, and a letter twenty miles. The piece of timber, technically called the plate, on which the rafters of the roof of a meetinghouse in New Brunswick rested, was carried nearly a quarter of a mile, and lodged in some trees beyond the Raritan. The fields, on the other side of that river, were strewed with shingles torn from the houses in the town.

After maturely considering all the facts, I am led to suggest that a tornado is the effect of an electrified current of air, superseding the more usual means of discharge between the earth and clouds in those sparks or flashes which are called lightning. I conceive that the inevitable effect of such a current would be to counteract within its sphere the pressure of the atmosphere, and thus enable this fluid, in obedience to its elasticity, to rush into the rarer medium above.

It will, I believe, be admitted, that whenever there is sufficient electricity generated to afford a succession of sparks, the quantity must be sufficient, under favourable circumstances, to be productive of an electrical current; and that light bodies, lying upon one of the electrified surfaces, may be attracted more or less by the other.

The phenomena of the rise and fall of electrified pith balls, called electrical hail, sufficiently justify this last mentioned statement; while the continuous stream is illustrated by the electrical brush, or the blast of air produced by a highly electrified point.

It will also be conceded, that thunder and lightning are caused by discharges of electricity between the earth and clouds, analogous to those of a Leyden jar or pane; the air performing the part of an electric in place of the glass, while the cloud acts as a coating.

It follows that the phenomena above mentioned as liable to arise between oppositely electrified bodies, may be expected to take place between the clouds and the earth, with effects as much exceeding those produced by human agency, as the snap and spark of an electric battery are exceeded by thunder and lightning. If in the one case pith balls and other light bodies are lifted; in the other, water, trees, houses, haystacks and barns may be powerfully affected.* If from a point electrified by a human contrivance, a blast of air is induced; it is as-

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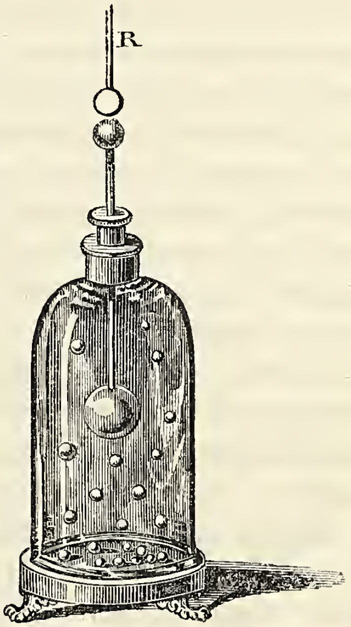

* This figure affords an illustration in miniature of the rise and fall of bodies situated between oppositely electrified surfaces, which, in the gigantic operations of nature, are conceived to be the exciting cause of the tornado. The phenomena represented by it are designated in Pixii's catalogue as "grelé electrique," and may be thus explained. A metallic rod supports one ball within the bell glass, another without, so as to be in contact with the knob of another rod R, proceeding from the conductor of an electrical machine in operation. The brass ball being by these means intensely electrified, attracts some of the pith balls which lie upon the metallic dish in which the bell is situated, and which should communicate with the cushions of the machine. As soon as the pith balls come into contact with the electrified ball, becoming similarly excited, agreeably to the general law they recede from each other and are attracted by the oppositely electrified dish. Reaching the dish, they attain the same electrical state as at first, and are, of course, liable to be attracted again.

suredly not unreasonable to ascribe to the analogous electrical apparatus of nature, aided by the elasticity of the air, a vertical hurricane. It was under the well founded impression that lightning may be superseded by a current, that we have been instructed by Franklin, to surmount our lightning rods by metallic points, by which electrical discharges from thunder clouds are expected to be conveyed to the earth gradually, which might otherwise pass in sparks of lightning of a formidable magnitude.

If, then, it be demonstrated that a continuous discharge of electricity may become the substitute for lightning, and that within the sphere of the discharge the air may be so lifted as to counteract its gravity; it is in the next place only necessary to advert to facts perfectly well known, in order to point out a cause of acceleration sufficient to account for the well known violence of the tornado.

At the height of fifteen miles, the air has been ascertained to have less than one-thirtieth of the density of the stratum next the earth. Of course this substratum would exercise a force nearly equal to the atmospheric pressure, or about fourteen and a half pounds to the square inch, in order to attain the space occupied by the rare medium, to which allusion has been made. It follows that if the weight of the superincumbent air were removed or counteracted, that the inferior stratum would rise with explosive violence.

While the air is thus carried upwards by the concurrent influence of electrical attraction, and the reaction of its own previously constrained elasticity; other bodies are lifted, both by electrical attraction, and the blast of air to which it gives rise. Hence houses within the sphere of the excitement are burst by the expansion of the air which they contain, their walls being thrown outwards, and their roofs carried away; while, by the afflux of the atmosphere requisite to the restoration of its equilibrium, trees, houses and other bodies are thrown inwards towards the vertical current, from before, as well as from either side.

When once a vertical current is established, and a vortex produced, I conceive that it may continue after the exciting cause may have ceased to act. The effect of a vortex in protecting the space about which it is formed, from the pressure of the fluid in which it has been induced, must be familiar to every observer. In fact, Franklin ascribed the water spout to a whirlwind produced by the concourse of the atmosphere to a given point. His hypothesis was, as I conceive, unsatisfactory, because it did not assign any adequate cause for the concentration of the wind, or for the hiatus which was presumed to be the cause. This deficiency is supplied, if my suggestions be correct.

One fact, of which I am myself a witness, cannot be explained without supposing a gyratory force. About six feet of a brick chimney, without being thrown down, were so twisted on the remaining inferior portion as to be left with its corners projecting.

I have hardly deemed it necessary to advert to the cause of the progressive motion of a tornado, since that would appear evidently due to the current of the atmosphere within which it may be created.

I believe that the electrical excitement which gives rise to atmospheric discharges of electricity, in whatever form they may occur, is usually ascribed to the chemical changes taking place in the atmosphere; especially the formation or condensation of vapour.

Another view of this subject has suggested itself to my mind. It is known that the atmosphere acts generally as an electric, while the earth acts as a conductor of electricity; and since the electric fluid passes through an exhausted receiver with great facility, it results that the rare medium which exists at a great elevation, is equivalent to another conductor. Hence it is evident that there are three enormous concentric spaces, of which that which is intermediate contains an electric, to which the others may act as coatings. When the tendency of electric fluid to preserve an equilibrium is taken into view, I believe myself justified in the inference, that not only the space occupied by the globe, but the region beyond our atmosphere, or where the air is sufficiently rare to act as a conductor, must abound with electricity. Thus the atmosphere is situated between two oceans of electricity, of which the tension may often be different. Between these electric oceans, the clouds, floating in the non-conducting air, must act as movable insulated conductors; and from the excitement consequent upon induction, chemical changes, or their proximity to the celestial electric ocean, must be liable to be electrified differently from each other, and from the terrestrial electric ocean.

The phenomena of thunder storms may arise, from the passage of electricity from one electric ocean to the other being facilitated by an intervening accumulation of the clouds, or in consequence of discharges from one insulated congeries of clouds to another through the earth.

The aurora borealis may arise from discharges from one ocean to the other of electricity, which, not being concentrated by its attraction for intervening clouds within air sufficiently dense to act as an electric, assumes the diffuse form which characterizes that phenomenon.

Falling stars may consist of electric matter, in transitu between one portion of the celestial electric ocean and another, tending to restore the equilibrium when disturbed. They may, in fact, consist of electric matter, passing from one mass of moisture to another; as it may be imagined that in an expanse so vast, in which the tension is so low, there may be a great diversity as respects the quantity of moisture existing in different parts. Indeed, it may be conceived that at times the clouds, insulated from each other, may make their reciprocal discharges through the region occupied by the celestial ocean.

I have been informed by my intelligent friend, Mr Quinby, who resided for some time in Peru, at an elevation of fifteen thousand feet above the level of the ocean, that the clouds in that elevated region are far more electric than in the lower country of the same latitude; and that, on this account, it was considered as dangerous, at times, to travel in the "*sierras*," or table land. Possibly thunder storms are more frequent in warm weather, in consequence of the greater elevation which the clouds then attain, and their consequent approximation to the celestial ocean of electricity.

Consistently with the hypothesis which I suggested in my essay on the gales of the United States, the enduring rains which accompany those gales are attributed to the contact of an upper warm and moist current of air, with a lower current of the same fluid at an inferior temperature, and moving in an opposite direction. It would follow that, on such occasions, the electricity of the upper region would be diffused among the clouds within the upper stratum, without reaching those existing within the lower current. But in such cases neither stratum would be sufficiently insulated and restricted in its extent to transmit the electricity in a concentrated form, or to be liable to the intense excitement necessary to produce a tornado or lightning.

## FACTS AND OBSERVATIONS RESPECTING THE TORNADO WHICH OCCURRED AT NEW BRUNSWICK, NEW JERSEY, IN JUNE LAST, ABSTRACTED FROM A WRITTEN STATEMENT MADE BY JAMES P. ESPY, M. A. P. S.

*By the Author of the preceding Article.*

The tornado was formed about seven and a half miles west of New Brunswick, and, moving at the rate of about twenty-five or thirty miles in an hour, terminated suddenly at Amboy, about seventeen and a half miles from the place of its commencement. It appeared like an inverted cone, of which the base was in the clouds, and the vertex upon the earth. It prostrated or carried off every movable body within its path; which was from two hundred to four hundred yards wide. Trees which were embraced successively within its axis were thrown down in a direction parallel to its path; those on either side always pointing towards some point which had been under its axis. Houses were unroofed, and, in some instances, unfloored; in others, their walls were thrown down outwards, as if burst by an explosion. There are two facts stated by Mr Espy, and confirmed by professor Bache, which demonstrate fully the existence of an hiatus. In a house which was exposed to the vertical influence of the tornado, a sheet was lifted from a bed, and carried into a fissure made in the southern wall, which subsequently closed and retained it. The same result was observed in the case of a handkerchief, similarly fastened into a fissure in the northern wall. In some instances, frame buildings were lifted entire from their foundations. Joists and rafters were torn from a house and thrown down at the distance from it of about four hundred yards, and in a direction opposite to that in which the trees not lifted from the earth's surface were prostrated. Of course lighter bodies, such as shingles, hats, books and papers, and branches and leaves of trees, were carried to much greater distances. There was no general rain, but hail and rain accompanied the fall of the other bodies. The tornado lasted, in any one place, for but a few seconds: the whole of the damage done at a farm having been accomplished, as the farmer stated, while he was passing from the front to the rear of his mansion, so that, by the time that he reached the back door, there was a perfect calm. Meanwhile, his house and barn were unroofed, and all the neighbouring trees thrown down. The noise which accompanied the phenomenon was by every witness described as terrific, being best exemplified by the rumbling of an immense number of heavy carriages. Every object in its path was bespattered with mud on the side towards that from which it advanced. Houses looked as if roughcast, and individuals were so covered with dirt as to be disguised.

Some thunder and lightning attended the tornado. Some trees, which resisted the onset, yielded subsequently; and hence were piled upon those which had fallen earlier. The weaker trees were undermost, and pointed in the direction in which the tornado approached; while the stronger were on the top, pointing in the direction in which it moved away.

Four different places were noticed, where all the trees lay, with their summits directed to a common centre. In the middle of one of these localities, the house was unroofed, and the handkerchief and sheet were lodged within the fissures in the walls, as already stated. The windows in the same house were all broken, and much of the glass thrown outside. From the evidence, Mr Espy infers that the apparent height of the tornado was about a mile. He states that there were, on the same day, two other tornadoes about seventeen miles apart; and of which the nearest was about the same distance from that of New Brunswick. He conceives that the phenomena all concurred to demonstrate an "inward motion from all directions towards the centre of the tornado, and an upward motion in the middle." These statements of Mr Espy are confirmed by professor Bache.

One fact of some importance has not been mentioned by Mr Espy, which was observed by persons who were upon the ground during, or soon after the catastrophe. I allude to the partial withering of the foliage of those small trees or shrubs, which, from their suppleness, were like the reed in the fable, neither uprooted nor overthrown. This unpleasant effect was perceptible when I visited the scene. Each leaf was only partially withered. As it would be inconceivable that mechanical laceration could have thus extended itself equably among the foliage, a surmise may be warranted that the change was effected by the electricity associated with the tornado.

### *Concluding Remarks by the Author of the Article.*

I ought, perhaps, sooner to have acknowledged that I am aware that it has often been suggested that water spouts might be caused by electricity; but the conjecture has not, as far as my information goes, been heretofore supported by any satisfactory explanation as to the mode in which such a tremendous power could arise from that source. That I am warranted in this impression, will, I trust, appear evident from the circumstance that two of the most distinguished among the late writers in the department of science to which the subject belongs, seem to admit, or to demonstrate, their inability to afford any explanation. I allude to Pouillet, and Despretz.

In his treatise on meteorology, Pouillet introduces two narratives respecting tornadoes, which were analogous in every essential point to that of New Brunswick. Especially the existence of an hiatus is proved by the allegation that the walls of prostrated houses were thrown down outwards. A labourer was first urged forwards, in the next place lifted, and lastly overthrown.

The learned and ingenious author concludes with these remarks. "Comment cette puissance, quelquefois si prodigieuse, peut-elle prendre naissance au milieu des airs? C'est une question, il faut de dire, à laquelle la science ne peut faire aucune réponse précise. De toutes les conjectures vagues et hasardées, que l'on peut faire sur l'origine de ce météore, la moins invraisemblable est peut-être celle que le regarde comme un tourbillon d'une excessive intensité. Mais une discussion sur ce point nous semblerait prématurée; il faut multiplier les observations, et constater avec plus de précision toutes les circonstances de ces phénoménes."—*Elemens de Physique Experimentale et de Météorologie, vol. 2, p. 727.*

All the information respecting tornadoes afforded by Despretz is comprised in the following paragraphs, which I quote in his own words.

" *Trombe.* La trombe se montre en mer et sur la terre; tantôt elle semble sortir du sein de la mer, et s'élève jusqu'aux nuages; tantôt elle descend des nuages jusqu'à terre.

"C'est une colonne d'eau cônique qui tourne sur elle-même avec une grande vitesse; elle a quelquefois jusqu'à plus de deux cents mètres de base. Elle est très-commune entre les tropiques: les navigateurs passent rarement près des côtes de Guinée sans en apercevoir plusieurs.

"Les trombes produisent des effets terribles; elles déracinent les arbres, renversent les faibles habitations, soulèvent les voitures, etc.

"On peut se faire une idée des trombes par les tourbillons de pouissiére qui se forment tout à-coup, en été, sur les routes, et qui tournent sur eux-mêmes avec une grande rapidité."—*Traité Elementaire de Physique, paragraph* 656, *page* 828, *par C. Despretz.*

In Nicholson's Journal, quarto series, London 1797, vol. 1, page 583, there is an interesting account of some tornadoes seen from Nice, illustrated by engravings, by M. Michaud, who appears to consider them as the effect of electricity, and infers that he could produce the phenomenon in miniature by the aid of a machine, as thunder and lightning are by the same means illustrated. This I have found to be erroneous, as far as my experience goes, and from a cause which is, agreeably to my hypothesis, quite evident. I mean the absence of the co-operating influence of the air when emancipated by electric attraction from the confinement arising from its own weight.

The theoretic remarks of Michaud are very brief, and, to me, scarcely intelligible, as he does not inform us in what way he supposes the electric fluid to operate.

I have understood, since I conceived my hypothesis, that Beccaria ascribed water spouts to electricity, but I have not had the advantage of learning by what reasoning he justified his inferences. However, should it appear that I have made, through the want of information, any undue claim to priority, I shall cheerfully do justice to any philosopher whose speculations I may have overlooked.

## ARTICLE VII.

### *Description of an Air Pump of a new construction, which acts either as an Air Pump, or a Condenser, or as both; enabling the operator to exhaust, to condense, to transfer a Gas from one cavity to another, or to pass it through a Liquid. By R. Hare, M. D., &c., &c., &c.*

This pump has one iron chamber,* one piston, and four valves. When in operation, it is always simultaneously exhausting and condensing; and, of course, accomplishes as much, in a given time, as two chambers of the usual construction, of the same calibre and stroke. A suction valve is placed at each end of a steel rod, which slides through the packing of the piston,† so as to be air tight, and to be pressed in opposite directions alternately. It is of such a length, that while it forces one valve, towards which the piston moves, against its seat, closing a corresponding aperture, it withdraws the other valve from its seat, and, consequently, opens the aperture with which this valve corresponds. Hence, with every reversal of the motion, the aperture previously opened will be shut, while that previously shut will be opened. Between the apertures thus alternately opened and shut, and the valve cock A, a communication is made by means of a forked leaden pipe, communicating with the valve cock at A, and with the apertures at B and C. The valve cock, by means of a gallows screw D, communicates, when desirable, with any receiver by another flexible leaden pipe P.

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* The diameter of the chamber in the instrument represented in the figure is three inches; the length is ten and a half inches, allowing a stroke of about eight inches, taking off the thickness of the piston. In order to render this instrument insusceptible of injury from mercury, it was constructed altogether of iron or cast steel.

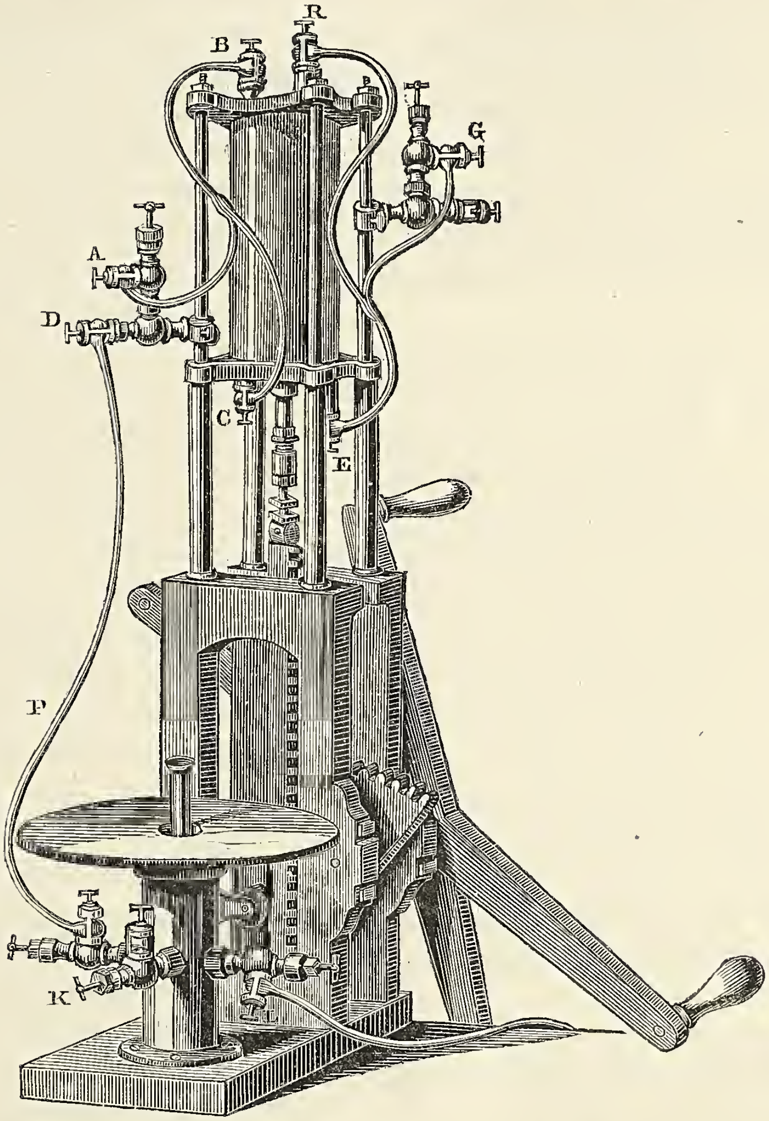
† This contrivance was suggested to me by an excellent pump with glass chambers, obtained many years ago from Pixii. In that pump a steel rod is made to open and shut one valve: in mine the same rod opens and shuts two valves.

Two other analogous and corresponding apertures E R, which communicate in like manner with a valve cock G, are furnished with two valves opening outwards. These, when not subjected to any pressure from within the chamber, are kept in their places by spiral springs. They act as valves of efflux, and, like the valves in other condensers, are opened by the pressure of the air condensed by the piston as it approaches them, and are shut by the springs when the piston moves in the opposite direction. It is well known, however, that this mode of opening valves, if unassisted, always allows a small portion of condensed air to remain in that portion of the chamber and of the passage leading to the valve, which the piston cannot be made to occupy entirely. This disadvantage is diminished in the case of the valves which I am describing. A stem proceeding from each valve enters the chamber so far, as that the piston cannot finish the stroke without coming in contact with the stem, and moving the valve sufficiently to allow the air to escape, without suffering any resistance from the valve and its spring.

The means by which the apertures of the suction valves communicate with a valve cock A, and may be made to communicate with the receiver through the pipe P, have been explained. By like means the communication, existing between the apertures of the valves of efflux and a valve cock G, may be extended from this valve cock to any receiver. In fact, it is only necessary to vary the situation or number of the pipes, by which communications with the chamber are effected, in order to cause the apparatus to perform the part of an air pump, a condenser, or both. When employed to transfer air, it would be more correctly designated as a forcing air pump, than as a condenser.

The disk of brass in front of the pump, serves as an air pump plate, when connected with the pump by means of the pipe P, as represented in the drawing. It is supported on a hollow brass cylinder, furnished

DR HARE'S SUCTION AND FORCING AIR PUMP.



with valve cocks as at K L, in order to allow various experiments to be performed by means of the tube in the axis, surmounted by a cup of copper. The tube being open at the lower end, the cup is accessible to an incandescent iron. The contrivance facilitates the exposure of substances to heat, either in vacuo, or in any gas. When boric acid and potassium are thus heated, boron is evolved. By means of a similar arrangement, heating chloride of calcium with potassium, I obtained a potassuret of calcium, which decomposed water and yielded a solution which was rendered milky by carbonic acid.

When a glass globe of fifteen gallons is exhausted over this plate, and filled with oxygen gas, phosphorus having been previously placed in the copper cup, on heating the phosphorus, a combustion ensues of transcendent splendour.

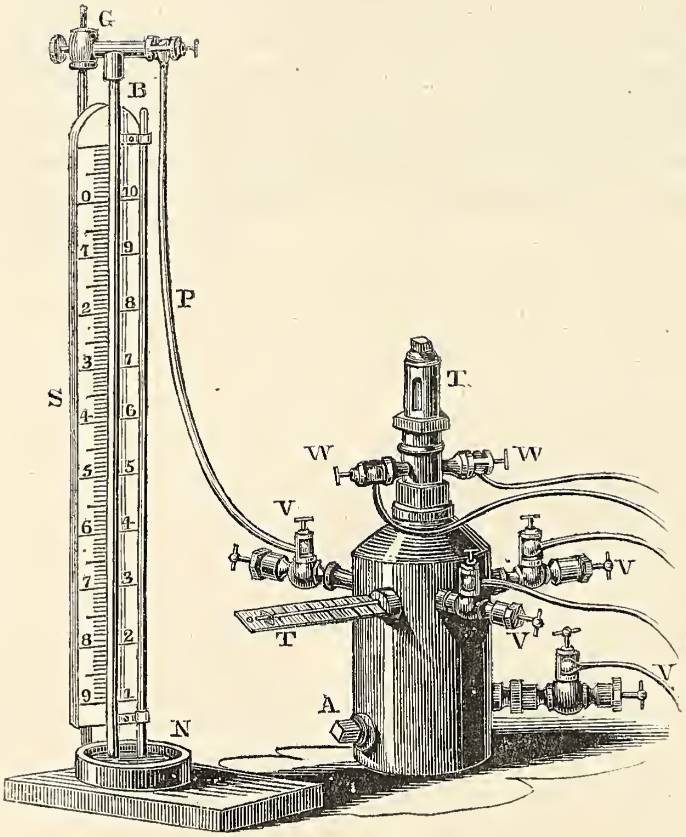
For this and other experiments, the hollow cylinder, which supports the air pump plate, may be screwed into a hole in a table and placed at any convenient distance from the air pump. With this view, there is a conical screw cut upon the lower end of the cylinder.

The mechanism by which the piston is moved, is too obvious to need description. There is, however, a peculiarity in the construction of the piston rod, which is of great utility. The rod is hollow, having been sufficiently reduced in diameter from a piece of gun barrel by the wire drawing process. The bore of this *hollow* rod is occupied by a solid rod, which extends from the metallic disk, at the farther end of the piston, to the rack. To the other disk, the hollow rod is fastened. The leather packing between the disks, being turned in the lathe so as to fit the calibre of the chamber accurately, is made more or less tight by the action of a screw just above the rack. Hence the pressure may be regulated without taking the pump apart, which is always troublesome, and, at some periods impracticable within the time at command.

With respect to the efficacy of this pump, satisfactory proof was given some time since, at the Franklin Institute, when it raised the mercury very near to the height of that in the Torricellian tube.

Having been in possession for many years of an elegant air pump with glass chambers furnished by Pixii, we have been induced to give the preference to the new instrument, in all cases where a perfect exhaustion has been desirable.

Of the three valve cocks, one usually communicates with a gage; since, instead of an instrument of that nature permanently associated with the pump, and which is subjected to exhaustion by means of a lateral communication with the perforation leading to the cavity of the receiver, I employ a movable barometer gage, which is made to communicate with the receiver directly. The operator is thus enabled to observe the quantity of gas in the receiver, after the communication with the air pump is arrested by closing the valve cock through which it was established. An exemplification of this method of manipulating will be afforded by the apparatus and eudiometrical process, described in the next article.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# ARTICLE VIII.

## *Of an Improved Barometer Gage Eudiometer. By R. Hare, M. D., &c., &c., &c.*

About eight years ago I published an account of a hydro-oxygen eudiometer, in which the measurement of the gases was effected by means of a barometer gage. In the apparatus then employed, the receiver was of glass, and was, of course, fragile. Subsequently I employed a stout iron bottle in lieu of the glass.

The essential constituents of this apparatus are an air tight vessel, sufficiently strong, and having screw apertures for the insertion of valve cocks, V V V, a thermometer T, and a galvano ignition apparatus* W W; also a barometer gage G, communicating by a leaden tube with the vessel through one of the valve cocks.

An air pump, pneumatic cistern or trough, and reservoirs for gas, are necessary auxiliaries.

It is an important characteristic of the barometer gage eudiometer, that it is applicable on a much larger scale than any other. It is only necessary to make the requisite apertures, and tap them for appropriate screws, in order to transfer the valve cocks, thermometer and ignition apparatus, with all the essential means of operating, to any air tight cylinder of any size ; to a large cannon for instance, the mouth

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* This is the name by which I have designated it in my text book.

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being closed. The sources of inaccuracy, if any exist, must lessen in proportion to the result, as the quantity acted upon is augmented. It would, of course, be safer to extend the cylinder in length than in diameter.

## *Description of the Gage.*

It is well known, that if a vertical glass tube communicate, through its upper orifice, with a receiver, while its lower orifice is situated beneath the surface of an adequate quantity of mercury, in any convenient receptacle; on exhausting the receiver, the metal will rise in the bore of the tube in proportion to the quantity of air removed. Hence, if zero of the ascending column of degrees, counting upwards from one to ten, be placed on a level with the surface of the mercury in the receptacle at the foot of the gage tube G, the quantity of gas condensed or withdrawn will be as the number of degrees opposite the surface of the column of the mercury in the gage tube.

Again, supposing it were possible to exhaust the vessel perfectly, the column of mercury in the gage, would attain the height of a well filled Torricellian tube. By having such a tube by the side of the gage tube, as represented at B in the figure, its orifice communicating with the mercury of the same receptacle, and placing zero of the descending column of graduations on a level with the surface of the mercury in the Torricellian tube, the quantity of air in the receiver will always be as the number of degrees, between the surface of the mercury in the gage and the surface of the same metal in the Torricellian tube.

The scale comprises ten divisions, each containing ten subdivisions. The whole scale may therefore be estimated to divide the capacity of a receiver into ten volumes, or into one hundred, whenever the zeros of the right and left hand columns of degrees coincide simultaneously, the one with the surface of the mercury in the receptacle, and the other with that of the Torricellian column. But on this it were vain to rely, since the altitude of the Torricellian column is liable to vary while the scale remains unchanged. This difficulty is, however, easily surmounted by restricting the length of the graduated part of the scale to the minimum height of the mercurial column, or twenty-seven inches; and employing an excess of hydrogen when the quantity of oxygen is to be ascertained, and an excess of oxygen when the quantity of hydrogen, or hydrogen and carbon, are in question; the excess in either case, being made equal to the difference between twenty-seven inches, and the height of the Torricellian column. With this precaution, the quantities introduced or withdrawn, will always be to each other as the changes which they produce in the column of mercury in the gage tube. The rise of the mercury in the tube, will cause the surface of it in the receptacle D to be lower; but the breadth of this vessel is so great, and the descent of the mercurial surface in it is so inconsiderable, that no error worthy of attention is thus created.

I ought to mention, that the cavity of the gage tube ought to be so small in proportion to that of the receiver, as to create no error worthy of attention.

### *Description of the Galvano Ignition Apparatus.*

An iron cylinder, of about an inch in bore, includes another concentric cylinder, or tube of glass. A platina wire, which, by being made the subject of a galvanic discharge, is employed to ignite the gaseous mixture, occupies the cavity of the glass. Opposite to it, two openings are made in the iron, which serve for windows, enabling the operator to see the progress of the ignition, and, consequently, to know when to break the galvanic circuit, in order to avoid fusing the wire.

### *Method of Operating.*

In the engraving, a leaden tube is represented as making a communication between the gage tube and the cavity of the iron bottle, through one of the valve cocks. Let it be supposed that, by means of other valve cocks and tubes, like communications with an air pump, and one or more reservoirs of gas, are under the control of the operator.

In order to analyze the atmosphere, he should have at his command a communication with a bell glass containing, over water, a mixture of five parts of air and three of hydrogen; also with a reservoir of hydrogen.*

These arrangements being made, exhaust the bottles; and admitting two or three volumes of hydrogen, exhaust again. By repeating this part of the process, nothing but hydrogen will remain in the vessel. Let the zero of the descending scale be situated on a level with the surface of the mercury in the gage tube, and then admit eight volumes of the mixture, which will be known to have entered when the surface of the mercurial column has fallen to eight on that scale. All the cocks being closed, ignite the platina wire. The explosion will be known to take place, both by the flash and sharp noise which it produces. As soon as these indications are perceived, the cock communicating with the gage may be re-opened. Nearly three volumes of the mixture will be found to have disappeared, and by the time that the thermometer indicates the temperature to be in statu quo, it will be found that the deficit arising from the combustion will a little exceed that quantity.

In analysing gaseous compounds of carbon with hydrogen, this apparatus may be advantageously employed; due proportions of the carburet and of oxygen gas being previously mingled in an appropriate vessel over water. Suppose, for instance, olefiant gas were in question; one volume of it being mixed with four of oxygen: after the explosion, two volumes will be found wanting; because, in one volume of the carburet, there are two of hydrogen and two of carbon vapour. Each volume of the latter, will unite with one of oxygen, without altering its volume. The two volumes of hydrogen will take one of oxygen, and be condensed with it into water. Of course, in lieu of the five volumes introduced, two volumes of carbonic acid, and one residual volume of oxygen will remain.

By means of the forcing air pump, described in the preceding pages, the gas may be transferred to a receiver, and washed with ammonia, or milk of lime, and then allowed again to enter the iron bottle.

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* The necessary mixtures are effected either by means of the volumeters or the sliding rod gas measure, of which I published engravings and descriptions in Silliman's American Journal of Science, vol. 12, page 36, 1827; and in the London Philosophical Magazine for 1828, vol. 32, page 126.

Meanwhile, by due attention to the gage, the quantity which has been absorbed may be ascertained; and consequently, the proportion of carbonic acid resulting from the oxidizement of all the carbon in the gas subjected to analysis.

Instead of employing the forcing air pump, by substituting a large valve cock for the screw by means of which an aperture in the bottle at A is closed, mercury may be introduced through a funnel, and, by its pressure, the residual gas may be easily conveyed, by a flexible leaden tube, to a receiver over the mercurial reservoir, and analyzed in the usual way. For this purpose it is necessary that the valve cocks with which the mercury comes into contact, should be of iron or steel; and, accordingly, I employ such where mercury is to be used.

The gases may be supplied, without previous measurement and admixture, by receiving them into the bottle from their respective reservoirs, and measuring them as they enter, by means of the gage.*

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* I subjoin engravings of the self-regulating reservoirs which I employ in such eudiometrical experiments as are described in the preceding article; also of the calorimotor, by means

Fig. 1.

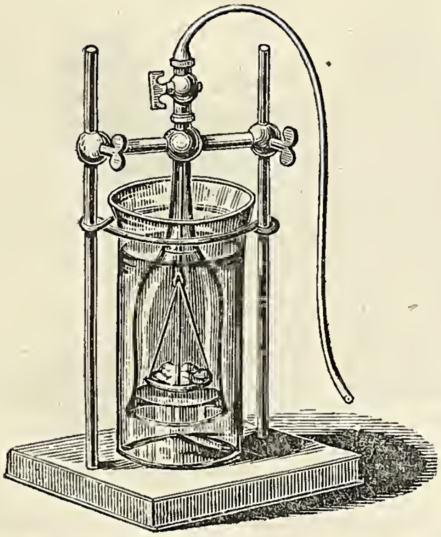
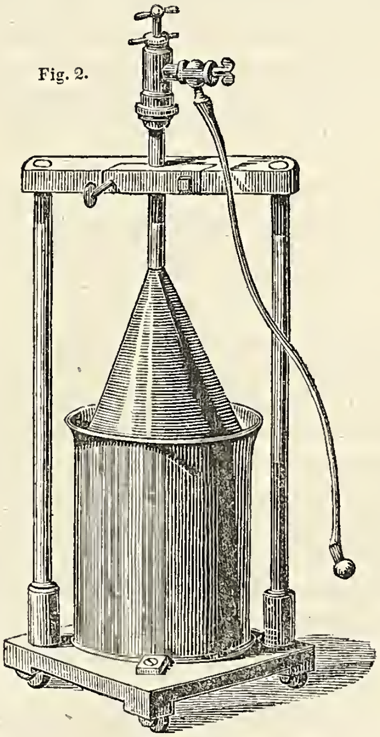


Fig. 2.



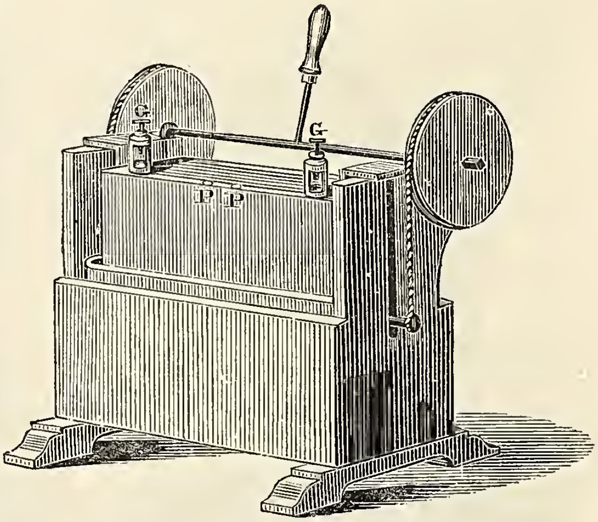
When hydrogen is employed to analyze the air, it should be the last admitted; since otherwise it is liable, from its lightness, to pre-occupy the cavity in which the platina wire is situated; so that some time would be required for its sufficient admixture with atmospheric oxygen to constitute a combustible mixture.

In this mode of operating, when the apparatus is once well arranged, the analysis of the air may be repeated as often as desired, and after any interval of time.

of which the ignition of the platina wire, and consequent inflammation of the gaseous mixtures are accomplished. There are two reservoirs, one of glass, fig. 1, the other of lead, fig. 2; the latter being about fifty times as large as the other.

As there is a perfect identity in principle of the construction in these reservoirs, an explanation of one will answer for both.

Suppose the glass jar to contain diluted sulphuric acid; the inverted bell, within the jar, to contain some zinc, supported on a tray of copper, suspended by wires, of the same metal, from the neck of the bell. The cock being open when the bell is lowered into the position in which it is represented, the atmospheric air will escape, and the acid, entering the cavity of the bell, will, by its reaction with the zinc, cause hydrogen gas to be copiously evolved. As soon as the cock is closed, the hydrogen expels the acid from the cavity of the bell; and, consequently, its reaction with the zinc is prevented, until another portion of the gas be withdrawn. As soon as this is done, the acid re-enters the cavity of the the bell, and the evolution of hydrogen is renewed and continued until again arrested, as in the first instance, by preventing the escape of the gas, and, consequently, causing it to displace the acid from the interior of the bell, within which the zinc is suspended.



This engraving will convey an idea of the calorimotor suitable to effect the ignition of the platina wire in the galvano ignition apparatus above described. It should contain two galvanic pairs, each consisting of two plates of zinc, 10 × 12, alternating with three of copper. The copper plates of one pair, and the zinc of the other being soldered to a common metallic strip, the other plates of zinc being soldered to one strip, the copper to another, each of the last mentioned strips is furnished with a gallows screw G G. Between these screws and those at W W, (see figure in the text) a communication is made by leaden or copper rods.

To complete the circuit, it is only necessary, to depress the handle attached to the pulleys, in order to raise the reservoir of diluted sulphuric acid, and thus to cause it to act on the plates.

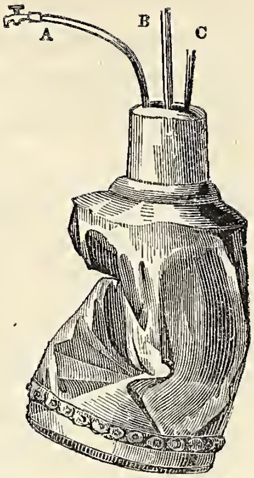
# ARTICLE IX.

## *On the Cause of the Collapse of a Reservoir while apparently subjected within to great Pressure from a Head of Water. By R. Hare, M. D., &c., &c., &c.*

In September 1834, I was requested by Mr Haydock, a respectable and intelligent plumber of this city, to call at his shop in order to see a copper reservoir, which had collapsed while apparently subjected to internal pressure, arising from a communication with the mains proceeding from the public water-works.

For the purpose of refrigerating the contents, the reservoir was placed in spring water, at the bottom of a well, so as to be at a small depth below the surface: receiving the river water by one pipe, it was made to deliver it by another.

The pressure of the water with which the city of Philadelphia is supplied, is known to be sufficient, when at its maximum, to command the most elevated rooms in our dwellinghouses. Hence, had the reservoir been burst, it would not have excited surprise; but the converse appeared inexplicable. The figure on the next page will convey a correct idea of the reservoir as it appeared when I examined it; or subsequently, when a drawing of it was made at the Franklin Institute, to which it had been removed, at the instance of some of the members of that institution.



A is a pipe with a stop cock to allow the air to escape on first filling the reservoir. B, a pipe by which a communication with the mains of the public waterworks was established. C, a pipe for delivering the water.

The height of the vessel was three feet; greatest diameter eighteen inches, least diameter twelve inches.

Some days had elapsed, during which I was unable to offer any explanation of the phenomenon; but having mentioned the occurrence to another highly respectable and intelligent plumber, Mr Ewing, he alleged that facts no less surprising had fallen within the range of his experience. He had known an opening made in a leaden pipe at one time, to be closed at another, by some unaccountable inward pressure; and, upon one occasion, a small fish to be caught in the fissure.

It then occurred to me that the phenomenon of the collapse had been the consequence of circumstances the inverse of those which are known to take place in the water ram of Montgolfier, in which water, while flowing rapidly in a trunk, being stopped suddenly in front, is made to produce a jet rising above the level of the head to which the current arrested is indebted for existence.

The momentum of the water which is in that case expended in a jet, must, in the case in which an arrestation takes place in the rear of a given portion of the stream, continue to propel that portion directly forwards, causing an hiatus or vacuum between it and the valve or cock by which the stoppage has been effected.

The inward pressure, or suction, arising from such a momentum, was demonstrated by Venturi;* and has latterly been ingeniously applied to the filling of syphons, and removal of back water from water wheels.

In this view of the subject then, we find the rationale of the collapse of the reservoir.

The current through the main being arrested at a point nearer the head than that from which the pipe supplying the reservoir proceeded, there was an hiatus produced within the main, and cavities therewith communicating, which caused the atmospheric pressure to be inadequately resisted, and consequently the reservoir, as one of those cavities, was crushed. No doubt the pressure of the spring water, in which the reservoir was situated, co-operated. At times our springs rise much nearer to the surface of the earth than at others.

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* Nicholson's Journal, 4to series, vol. 2, page 172.

When steam is made to pass through a pipe into cold water, a succession of expansions and condensations ensue, producing much noise and mechanical jarring, consequent to the alternate absorption and expulsion of the water. Agreeably to the rationale respecting the collapse of the reservoir, these effects should be productive successively of an inward and an outward pressure upon the surfaces of the pipes employed.

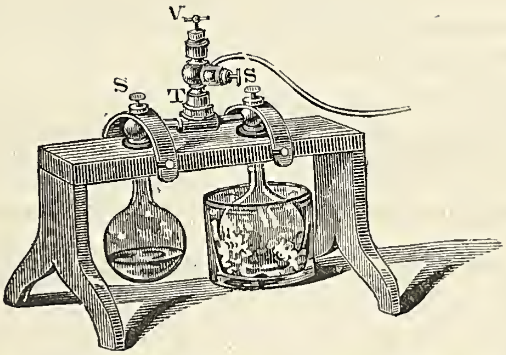
Some years ago, a pipe was submitted to me by Mr Ewing, which, while situated as above described, had been crushed by a force which seemed to have exceeded any which could, under any circumstances, be expected from the pressure of the atmosphere. Possibly an adhesion between the water and the metallic surface, may co-operate in the production of such results.

## ARTICLE X.

*Sundry Improvements in Apparatus, or Manipulation. By R. Hare, M. D., &c., &c., &c.*

### IMPROVED CRYOPHORUS.

Two flasks, of which the necks have flanged orifices, are so secured in a wooden frame, that by the pressure of screws S S, and gum-elastic disks, the orifices of a tube are made to form with them severally, air tight junctures. The orifices of the tube are furnished with brass flanges, which correspond with those terminating the necks of the flasks.



Midway between the junctures a female screw is soldered to the tube for the insertion of a valve cock V, by means of which, and a flexible tube extending to an air pump, the flasks may be exhausted, and then closed. A small quantity of water having been previously introduced into one of them, if, while the exhaustion is sustained, the other flask be refrigerated by ice and salt, the water will be frozen.[*]

The intelligent chemist will perceive that this apparatus may be applied to the purpose of desiccation by placing the article to be dried in one receptacle, and quick lime, chloride of calcium, or concentrated sulphuric acid, in the other. The orifice of the receptacles may be made larger without inconvenience. Two large cylinders, for instance, may be used.

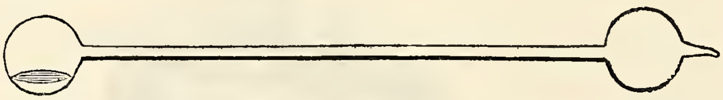
I propose, as soon as I have leisure, to apply the principle illustrated by this apparatus, to the distillation or desiccation of many substances which are liable to injury when exposed to heat, or air. I conceive that there is, by means of analogous apparatus, a fruitful field for improvement in the arts. I conceive that it may be employed in the preservation of meat, milk, fruit, vegetables, and the making of cheese; also in pickling and preserving.[†]

[*] For the information of readers who may not be chemists, I subjoin the following explanation of the cause of the congelation of the water.

So long as no condensation is effected, of the thin aqueous vapour, which, when water is present, must occupy the cavity of the instrument, that vapour prevents, by its pressure, or tension, the production of more vapour: but when, by means of cold, the vapour is condensed in one bulb, its evolution in the other, containing the water, being unimpeded, proceeds rapidly. Meanwhile, the water becomes colder, and finally freezes, from losing the caloric which the vaporization requires.

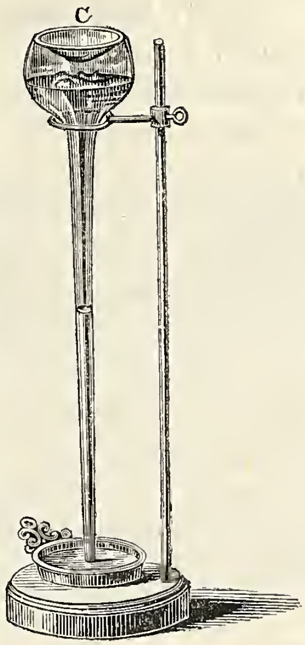
According to Wollaston, one grain of water, converted into vapour, holds as much caloric as would, by its abstraction, reduce thirty-one grains from 60° F. to the freezing point; and the caloric requisite to vaporize four grains more, if abstracted from the residual twenty-seven grains, would convert them into ice.

[†] This figure represents a very large Cryophorus, the blowing of which I superintended; and by means of which, about twelve years ago, I successfully repeated Wollaston's experiment.



This instrument is about four feet long, and its bulbs are about five inches in diameter.

## CULINARY PARADOX, OR EBULLITION BY COLD.



This figure illustrates a new and instructive method of effecting ebullition by cold.

The apparatus consists principally of a glass matrass, with a neck of about three feet in length, tapering to an orifice of about a quarter of an inch in diameter. The bulb is bulged inwards, in the part directly opposite the neck, so as to create a cavity capable of holding any matter which it may be desirable to have situated therein. In addition to the matrass, a receptacle, holding a few pounds of mercury, is requisite. The bulb of the matrass being rather less than half full of water, and this being heated to ebullition, the orifice should be closed by the finger, defended by a piece of gum-elastic, and depressed below the surface of the mercury; the whole being supported as represented in the figure. Under these circumstances, the mercury rises as the temperature of the water declines, indicating the consequent diminution of pressure within the bulb. Meanwhile, the decline of pressure lowering the boiling point of the water, the ebullition continues till the mercury rises in the neck nearly to the height of the mercury in the barometer.

By introducing into the cup formed by the bulging of the bulb, cold water, alcohol, ether or ice, the refrigeration, the diminution of pressure, and the ebullition are all simultaneously accelerated, since these results are reciprocally dependent on each other.

The advantage of this apparatus and method of operating, lies first in the certainty and facility with which the apparatus is secured against the access of the atmosphere; and in the next place, in the index of the diminishing resistance, afforded by the rise of the mercurial column.

## HYDRO-PNEUMATIC CISTERN.

Fig. 1. In Silliman's Journal will be found an engraving and description of a pneumatic cistern, which I employed in the experimental illustrations of my lectures for more than ten years; and which I should probably continue to use now, had not the command of water from the public works, put it into my power to dispense with the mechanism for keeping the water at a proper level. As I am now situated, any deficit of water is easily supplied from the pipes known here as the hydrant pipes, by which the city is supplied with water; and any excess is carried off by a waste pipe. Many chemists designate as a pneumatic trough or tub, apparatus for the purposes to which that in question is applied. Neither of these names is, in my opinion, as applicable to the apparatus which I have hitherto used, as that of cistern, to which I resorted; and although the last term be less suitable to the apparatus which I am about to describe, yet I beg leave to adhere to it for want of a better appellation.

A A, a water-tight platform, surrounded by a wooden rim, R R R R, rising above it about an inch and a half. B, C, D, three wells or cavities, each in the form of a hollow parallelopiped, with all of which the cavity bounded by the rim communicates, so that when supplied with water to the level of the waste pipe, this liquid fills the wells, and covers the platform to the depth of about three-fourths of an inch.

E, F, G, shelves, which severally move in grooves over the wells, so that they may be placed in the most convenient position. Under H is a waste pipe. At I is a hydrant pipe. K, a pipe for emptying the wells and casks, with all of which it may be made to communicate by cocks, when requisite. N, O, casks which act as gas holders, each having a communication with the cistern at Q or *q*, for letting in water from that source; the orifices being controlled by valves. By means of a pipe proceeding from its vertex, each gas holder communicates with a pipe or cock, at S or *s*.

To these gallows screws, flexible leaden pipes may be attached, for transferring gas either from one of the holders to a bell glass, or from a bell glass to one of the holders. When a communication is established between the cavities, either of these offices may be performed, accordingly as the pressure within the holder is made greater, or less, than that of the atmosphere. It will be greater when the valve for the admission of water is opened, that for letting it out being shut: and less when these circumstances are reversed.

Fig. 1.

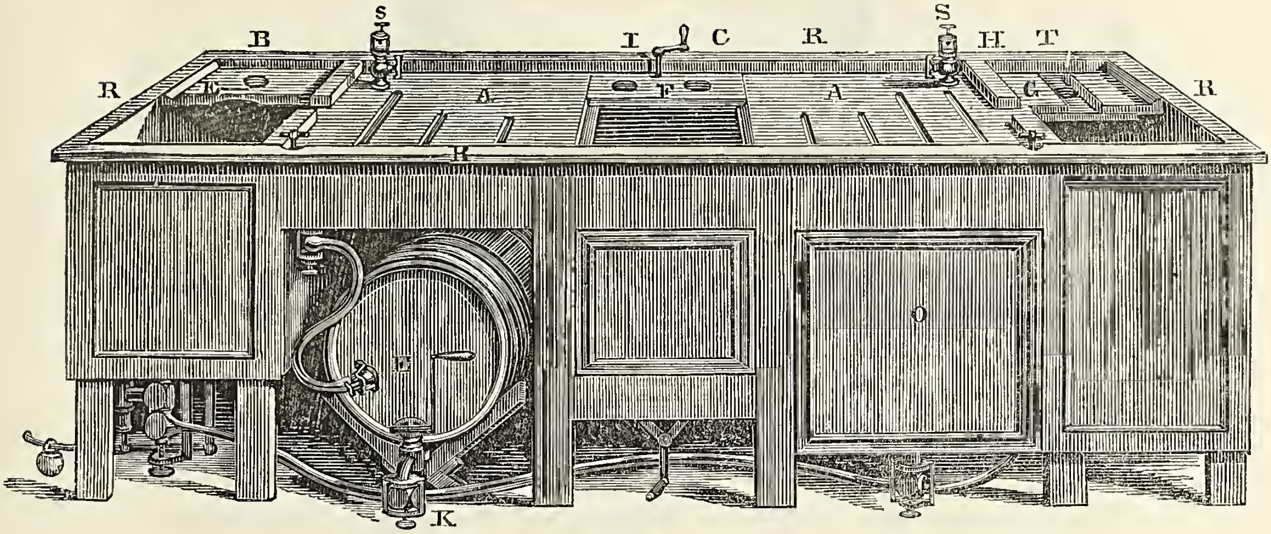


Fig. 2.

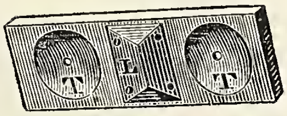
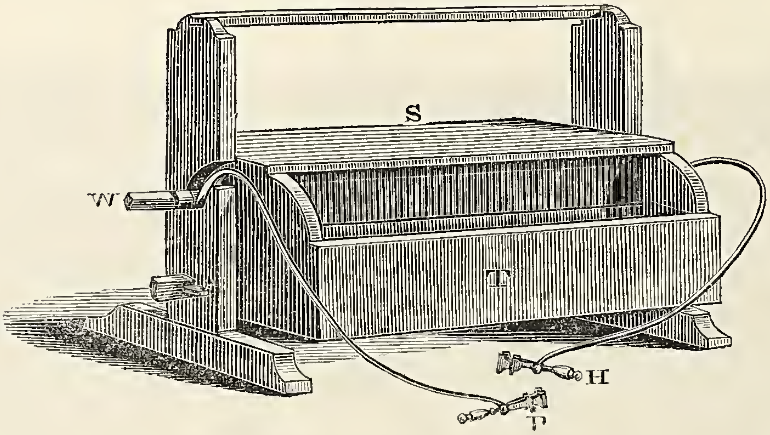


Fig. 2 affords a view of the lower side of the sliding shelf, in the wood of which it will be seen that there are two excavations, converging into holes. This shelf is loaded with an ingot of lead at L, to prevent it from floating in the water of the cistern.

## ENGRAVING AND DESCRIPTION OF VOLTAIC SERIES, COMBINING THE ADVANTAGES OF THE TROUGH OF CRUICKSHANK WITH THOSE OF THE DEFLAGRATOR.

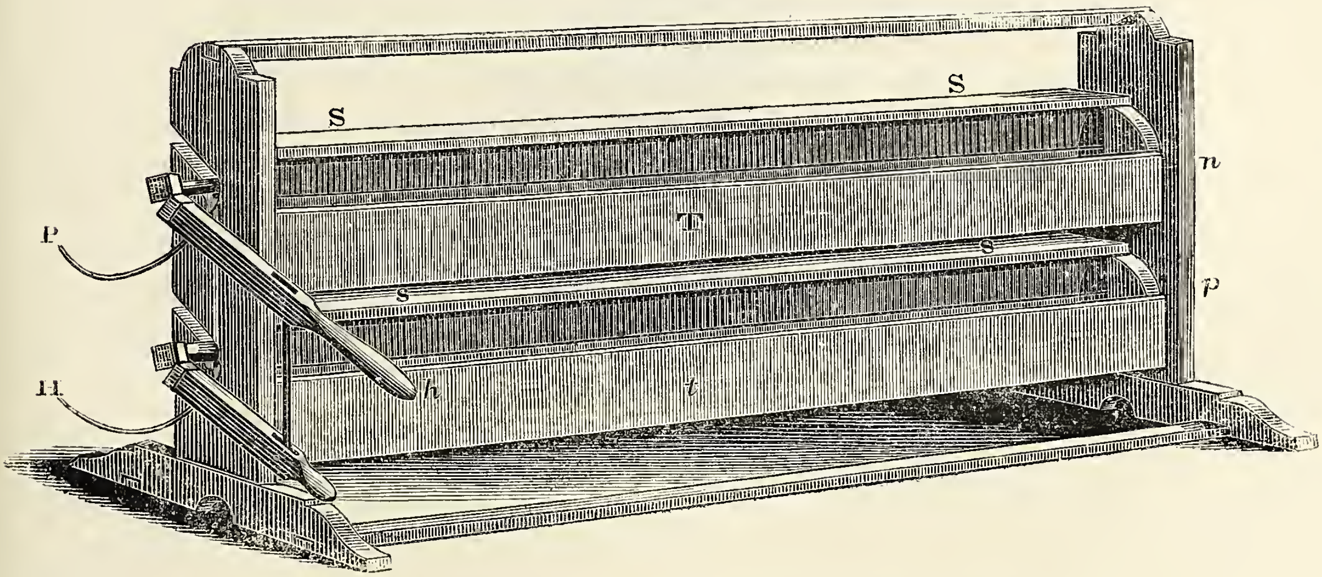
Fig. 1.



*Galvanic Deflagrator of one hundred pairs, of fourteen inches by eight.*

Fig. 1 represents a voltaic series, upon the plan of the trough of Cruickshank, associated with another trough destitute of plates, and of a capacity sufficient to hold all the acid necessary for an ample charge. The trough containing the series is joined to the other lengthwise, edge to edge, so that when the sides of the one are vertical, those of the other must be horizontal. The advantage of this arrangement is, that by a partial revolution of the two troughs, thus united, upon pivots which support them at the ends, any fluid which may be in one trough must flow into the other; and, reversing the movement, must flow back again. The galvanic series being placed in one of the troughs, the acid in the other, by a movement such as above described, the plates may all be instantaneously subjected to the acid, or relieved from it. The pivots are made of iron, coated with brass or copper, as less liable to oxidizement. A metallic communication is made between the coating of the pivots, and the galvanic series within. In order to produce a connexion between one recipient of this description and another, it is only necessary to allow a pivot of each trough to revolve on one of the two ends of a strap of sheet copper. To connect with the termination of the series, the leaden rods, to which are soldered the vices, or spring forceps, for holding the substances to be exposed to the deflagrating power, one end of each of the lead rods is soldered to a piece of sheet copper. The pieces of copper, thus soldered to the lead rods, are then to be placed under the pivots, which are of course to be connected with the termination of the series. The last mentioned connexion is conveniently made by means of straps of copper, severally soldered to the pivots and the poles of the series, and screwed together by a hand-vice. Each pair consists of a copper and a zinc plate, soldered together at the upper edge, where the copper is made to embrace the edge of the zinc. The three remaining edges are made to enter a groove in the wood, being secured therein by cement. For each inch in the length of the trough there are three pairs. In the series represented by Fig. 1, there are seven hundred pairs of seven inches by three; in that represented by Fig. 2, one hundred pairs of fourteen inches by eight. The latter will deflagrate wires too large to be ignited by the other, but is less powerful in producing a jet of flame between the charcoal points, or in giving a shock.

Fig. 2.



*Galvanic Deflagrator of seven hundred pairs, of seven inches by three.*

Fig. 2, on the foregoing page, represents a series which comprises two Cruickshank deflagrators, so constructed as to co-operate in one circuit by an adequate communication between their poles, and being so associated with a lever, as to be made, by means of it, to revolve simultaneously. They may be made to act either collaterally, as a series of 350 pairs, or consecutively, as 700. As the plates are seven inches by three, when used collaterally, they are equivalent to 350 plates of seven inches by six.

### COMBUSTION OF PHOSPHORUS IN NITROUS OXIDE GAS.

There is a striking backwardness in the oxides of nitrogen to part with their oxygen to phosphorus, until it be intensely ignited, either by an incandescent iron, or by the access of uncombined oxygen.

This characteristic in the case of nitrous oxide, may be illustrated by means of an apparatus like that employed for the combustion of phosphorus in oxygen* with a tall cylindrical receiver, and a tube descending through the neck, and along the axis of the receiver, terminating in a capillary orifice over the cup for holding the phosphorus. The upper end of the tube, outside the receiver, is furnished with a cock, to which a gum-elastic bag inflated with oxygen is attached.

Under these circumstances, the receiver having been exhausted, and filled with nitrous oxide; phosphorus, previously placed within the cup, may be melted without taking fire. But as soon as the cock communicating with the bag of oxygen is opened, an intense combustion ensues; since the oxygen, emitted in a jet from the capillary orifice of the tube, reaching the melted phosphorus excites it into an active combustion, which the nitrous oxide afterwards sustains with great energy.

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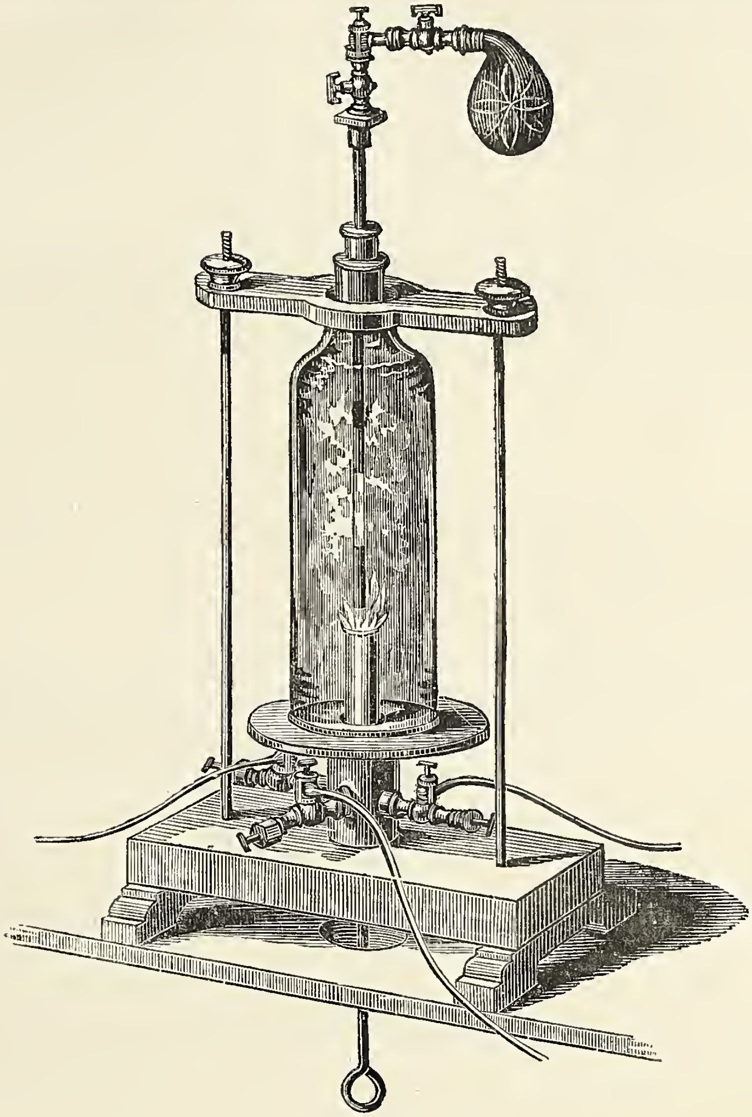
* See article on Forcing Air Pump, page 42.



COMBUSTION OF PHOSPHORUS IN NITROUS OXIDE.